E ENGINEERING MAGAZINE OF THE METAL-WORKING INDUSTRIES

METALS and ALLOYS

TERIALS AND DESIGN · METHODS AND PROCESSES · FEBRUARY, 1945

How to Evaluate Insulating Firebrick

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2. Light Weight for Low Conductivity
3. Stability
4. Volume Change
5. Manufacturer's Responsibility
6. Value

5

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METALS and ALLOYS

The Engineering Magazine of the Metal-Working Industries

VOLUME 21 • NUMBER 2 • FEBRUARY, 1945

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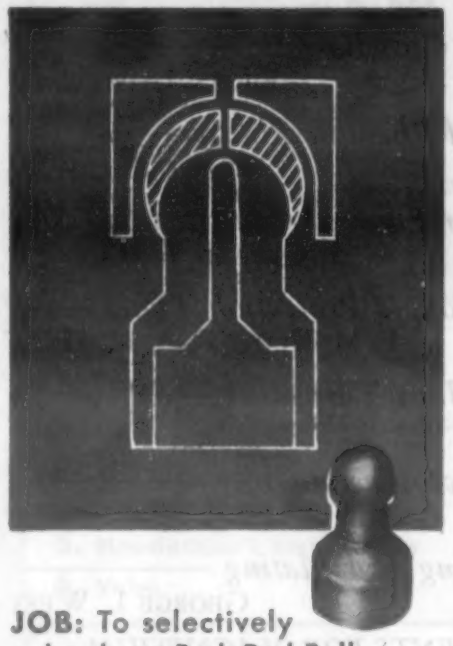
Next Month

M&A for March will feature another Materials and Methods Manual, this time a 12-page special section on "Alloys for High-Temperature Service"; an important article on Magnesium Alloy Forgings and another on Soldering with Low-Tin Solders; a symposium on Materials for Lightweight Construction; and articles on Metal Powder Friction Materials, Extruding Nickel Alloys, Refractory Concrete, etc.

INDUCTION HEATING CORPORATION

Data Sheet No. 12

CASE HISTORIES OF SELECTIVE HARDENING APPLICATIONS



JOB: To selectively harden a Push Rod Ball.

MATERIAL: SAE 3115 carburized.

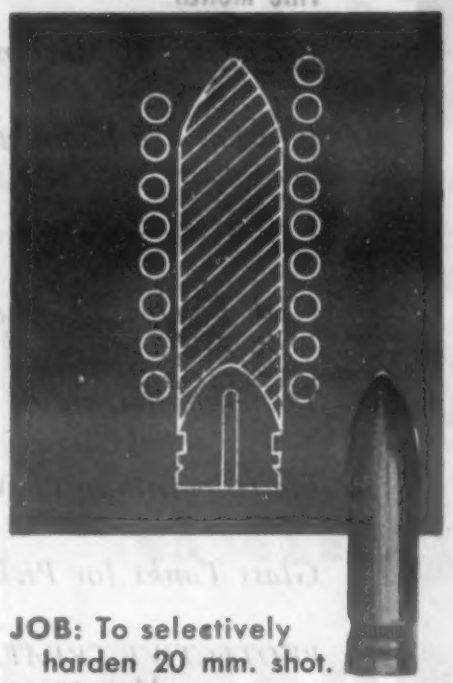
PRODUCTION: 30 per minute.

TEMPERATURE: 1500°F.

EQUIPMENT: One Thermonic No. 520 generator and conveyor table.

LOAD: Approximately full.

REMARKS: .030 case hardness obtained with immersion water quench.



JOB: To selectively harden 20 mm. shot.

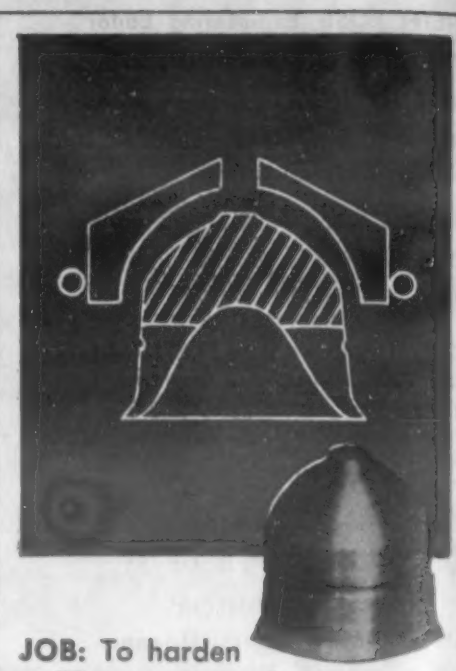
MATERIAL: SAE 4150 Steel.

PRODUCTION: 5 every 65 seconds.

EQUIPMENT: One Thermonic No. 1070 generator and an automatic single position table.

LOAD: Full 20 KWs or 1070 BTUs.

REMARKS: Rockwell C 62 obtained with immersion water quench.



JOB: To harden 57 mm. armor piercing caps.

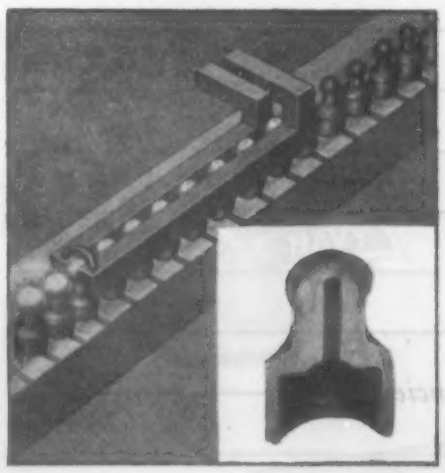
MATERIAL: SAE 4150 Steel.

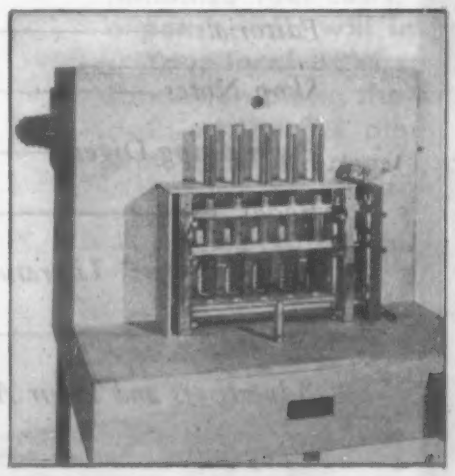
PRODUCTION: 6 at a time in 230 seconds.

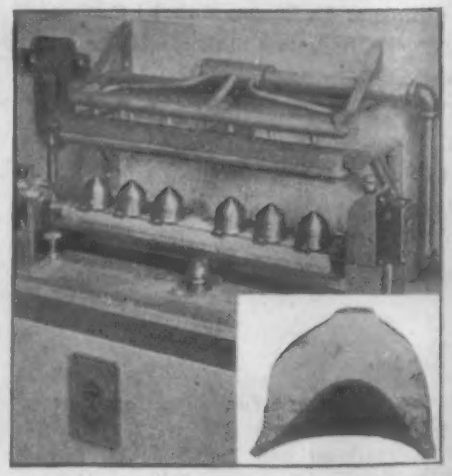
EQUIPMENT: One Thermonic No. 1070 generator and automatic quenching and unloading table.

LOAD: Full 20 KWs or 1070 BTUs.

REMARKS: Rockwell C 62 on top—57 on inside of cap, with spray water quench.







HELP AVAILABLE . . . The door to Induction Heating's Laboratory is wide open to those who will submit their metal treating problem and samples to our technicians. After a carefully conducted procedure, the arrived-at solution will be prepared as a detailed report for your study and consideration. This service involves no obligation.

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Engineers and Consumers Demand Information

At its annual conference in New York the Plastics Society heard two requests for information—one from representatives of engineers, the other from representatives of consumers. Both wanted a system that would enable them to peer behind trade names and find out what could be expected of a material in the way of performance.

Consumers asked for "informative labeling," so that they could think of the article in more explicit terms than just "made of plastic." It was pointed out that, with the wide range of properties offered by the various plastics, the buying public wanted to know what could be expected of a particular item. The engineers, however, wanted specific data upon engineering properties, so that they could judge of the suitability of a given composition for a definite purpose.

As far as the engineers are concerned, the Society of the Plastics Industry has the situation well in hand. A committee to classify the various plastics according to engineering properties has submitted a progress report in which a number system is offered, the numerical designation to give, in key form, several of the most important physical properties of the material designated. It follows in a general way the SAE classification system for metals, except that physical tests are substituted for chemical composition.

For the consumer, there is a tougher nut to crack. The word "plastic" is about as definitive as the word "metal" would be in describing the material of which an article is made, but at present it is difficult to see how the layman's need for informative labeling is to be met. Behind the word plastic is a mass of trade names that certainly will not clarify the situation. Chemical type names would be even worse.

The difficulty is an outgrowth of the industry. Once upon a time the department store customer could think of celluloid, and later of Bakelite. Now there are hundreds of compositions, each with a similar trade name.

In the metals field, the consumer can think of steel, and brass, and aluminum, and magnesium, and similar simple, broadly-inclusive names. If he, and more particularly she, wishes, steel may become stainless steel, or galvanized iron, or tinplate, and so on. The plastics industry in time will arrive at these broad consumer designations for a class of products, and inside this framework the individual companies may safely popularize their own trade names. —K. R.

That Common Interest

The community of interest among engineering, production and metallurgical personnel in materials and their processing methods is great and growing. As demonstrated in our November editorial the two questions "What materials shall be used for this product?" and "What methods shall be used for processing the materials and fabricating the product?" are increasingly being decided together as a single problem rather than separately. Inevitably this must bring into consultation materials engineers and production engineers, or production men and metallurgists, or metallurgists and design engineers, or three-way combinations of these.

(Continued on page 385)

RYERSON CERTIFIED STEELS

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With every alloy shipment from Ryerson stocks, you receive a Report giving accurate, informative data on the particular heat or heats of steel shipped on your order. Included in this Report is the following information relating to the alloy steel and its performance:

1. Chemical analysis and grain size.

2. Charted results of four separate Jominy End Quench Hardenability Tests made on samples of your heat of steel in the as-quenched condition and when quenched and drawn at 1000°, 1100° and 1200° F.

3. The interpreted physical properties for 1, 2, 3, and 4 inch rounds, quenched and drawn at the above temperatures. These include the tensile strength, yield point, percent elongation, percent reduction of area and the Brinell hardness.

4. A table of cooling rates for Jominy samples and round bars and a table showing physical properties in relation to hardness. From these you may interpret, with the aid of the Jominy test results, the physicals for rounds in other sizes than those indicated in 3.

5. Recommended working temperatures for your steel.

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IN STOCK: ALLOY STEEL • TOOL STEEL • ALLEGHENY STAINLESS • BARS • SHAPES • PLATES • SHEETS • TUBING • ETC.

Every reader engaged in practical design, production or metallurgical work or in general engineering supervision knows that this is so in his plant *or that it should be so!* Too many plants formerly ran into trouble because the designer said the part should be of this shape and made out of that material and the production man found when the job came through it just couldn't be done to specifications; so after considerable spoilage and broken tools they got together and changed the material specification to something satisfactory to both of them. Now they consult in the initial stages and keep in touch all along.

In one plant, the prime purpose of the metallurgical department was to "trouble-shoot"—to discover the reasons for failures of parts in service, since these were automatically assumed to be because of some deficiency in the material of the part. Finally, objecting to this post-mortem approach and armed with evidence that it wasn't always the metallurgy but often the whole material-design or the fabricating operations that were at fault, the metallurgists moved in and forced an overall conference of metallurgists, design and materials engineers and plant engineers during the design and production planning of each part. Now heat treated parts are specified where needed, copper and zinc parts are not placed together in corrosive service, brazing is required where welding would leave a brittle or a tempered zone, special heat treatments are specified for hard-to-machine steels—all *in advance* and therefore much more efficiently.

Many plants have set up parallel "materials engineering" departments in which are found design engineers and metallurgists and "process engineering" departments to which are attached plant engineers, practical production men and metallurgists, with the department heads in constant contact. A growing number of companies have "materials and processes" or "materials and process engineering" departments, each of which contains engineers, production men and metallurgists. At least one large aircraft plant has an assistant chief engineer solely responsible for materials and processes. Other companies have set up "materials-and-processes" or "materials-and-methods" committees comprising design, materials, production and metallurgical engineers, which must pass on each part before its design and production methods are fixed.

These are the more advanced setups that point the way. In the general run of metal-working plants the consultations are informal or the coordination is accomplished in the person of the chief engineer. But the common interest is there; each of them—the design or materials engineer, the production man, the metallurgist—has a major interest in the materials chosen for the product, from either the service or the workability standpoint, and in the processing methods used, from either the product-quality or the efficiency point of view. Because of this and because each recognizes that the others can affect his performance or results, they now work together in more and more instances.

METALS AND ALLOYS is simply the magazine about the things that bring them together—the materials for their products and the processing methods they are to use. And very good proof that that common interest among the three groups does exist and that it is embodied in this magazine is the pattern of M&A's circulation distribution—our readers are of all three types, approximately in the ratio 5:4:3 for engineers, production men and metallurgists, respectively.

—F. P. P.

Are Alloying Metals Past Their Hey Day?

Will producers of alloying metals such as nickel, chromium and tungsten have a good future for their products in view of the tendency to use leaner alloy steels such as those of the N.E. series? Inasmuch as success of a metal producer is usually measured by the yardstick of tonnage sold, have these producers reached and passed their peak? Particularly, too, since the N.E. steels, or their equivalent, are here to stay, according to a METALS AND ALLOYS survey?

In the first place a large share of materials engineers will consider "Emergency" steels just that and will insist on former pre-war generously-concocted alloys, which gave greater and safer latitude in treatment and processing. Secondly, the newer lean triple alloy steels will probably find very widespread and diverse uses, taking the place of plain carbon steels. We recall, for instance, the cut-rate hardware store of yesteryear. A steel garden trowel would hopelessly bend after a few applications to hard soil. The jaws of a wrench would soon nick, bruise and become inefficient. Thus there is a good chance that a greater volume of applications will increase the overall consumption of alloying elements despite the lesser content of alloying agent per unit of finished item.

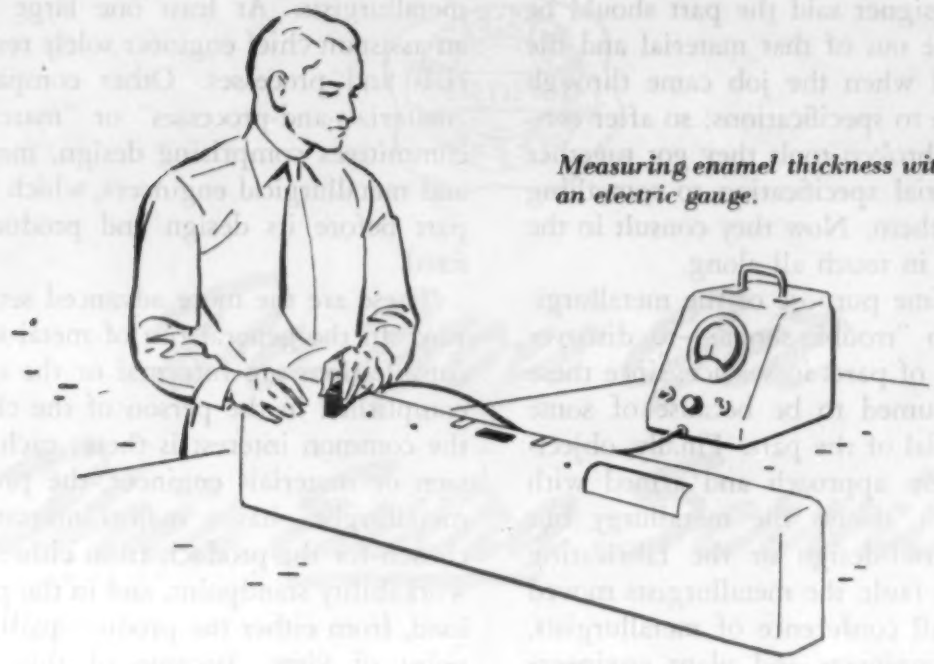
Thirdly, during the war emergency research was concentrated along the lines of using as little alloy per unit as possible for sake of conservation. In the post-war era research can be devoted to finding where high alloy steels are best suited, with the possibility of brand new uses being uncovered.

Fourthly, many of the higher alloy steels are used for qualities other than hardenability—greater tensile strength, fatigue or impact strength, strength/weight ratio, etc.—in which they are superior to the emergency steels and for which an increasing demand seems to be developing.

Finally, there seems to be a rule of the universe that a basic commodity that has once proved itself highly useful never really suffers from a more modern material. When the electric light supplanted the kerosene lamp, the death knell for kerosene was being sounded, many people said. But kerosene consumption has increased, due to expanded industrial uses.

So, if we owned any stock of the nickel or chromium or molybdenum producers, we certainly wouldn't sell it short!

—H.A.K.



Measuring enamel thickness with an electric gauge.

TI-NAMEL

Another New Creation by Inland Steel Company's Research Laboratories

The long awaited porcelain enameling base, which eliminates the necessity for a ground coat, is here! It is Ti-Namel, the new titanium alloy steel—the newest creation by Inland's research laboratories.

Ti-Namel is superior in every respect to older types of base metals. Its drawing properties are equal to the best deep-drawing steels. It does not age strain no matter how long it remains in storage before fabrication. Inland Ti-Namel Steel does not reboil. Therefore vitreous enamel finishes, equal to the best multi-coat ware, are obtained with white or color coat enamels applied direct to the base metal. This results in a thinner coat which reduces chipping hazards and increases the service-life of the ware.

Ti-Namel reduces reoperations, edging, and scrap. It is fired at lower temperatures, and in less time. In short, Inland Ti-Namel Steel increases shop output, lowers manufacturing cost, and assures superior vitreous enameled ware.

Pending patent applications on the new enameling process and product made thereby, are owned jointly by Inland Steel Company and The Titanium Alloy Manufacturing Company under trust agreement.

Write for copy of the Ti-Namel Bulletin and licensing agreement. Inland Steel Company, 38 South Dearborn Street, Chicago 3, Illinois. Sales Offices: Cincinnati, Detroit, Kansas City, Milwaukee, New York, St. Louis, St. Paul.

INLAND STEEL

Engineers and the Manpower Shortage

an Editorial

Engineers have a many-sided interest in the current critical manpower shortage and the various devices—legislative, managerial and technical—that may be applied to relieve it.

First, as Americans, engineers should be concerned that sufficient manpower be found or transferred to meet the most urgent front-supplying war-production needs of the moment. Skilled and unskilled labor must be shifted with the inevitable changes in requirements, and the manpower leak out of war production into "post war" jobs must be stopped. Voluntary means having failed of this purpose, compulsory methods must be applied. To the oft-heard charge that this is "un-American" we can only reply that if it is American to compel more than 8,000,000 draftees to leave their homes and jobs for the discomfort, horror or mortal danger of military and naval service at a pittance it is no less American to force some hundred thousands of unwilling among us to accept, retain (or fill without striking) specified wartime jobs in comparatively comfortable and completely safe surroundings and at what any enlisted man would call wonderful pay. The inexorable logic of this is obvious to engineers and we are sure they will support and cheerfully comply with such legislation as it develops.

Second, as Management's partners in our own plants we can assist in numerous ways to achieve intelligent manpower utilization. We can discourage complacency and oppose wherever we find it the false proposition that the war is practically over. Our influence in planning—either technical or administrative—can be thrown on the side of postponing any reconversion preliminaries that interfere with present or possible future war-production operations. And we must ourselves stay on our war jobs right to the end, for engineers are the most important of all the key personnel of wartime industry, as the WMC acknowledged last month in setting up a virtual blanket deferment for all technical and scientific occupations in its present list.

This leads us to the third and most important contribution engineers in the metal-working industries can make to solving the manpower problem—their technical influence, their control of the materials and methods used in war-product manufacture. Where new designs and procedures are being established, engineers can be particularly vigilant that these be such as require the minimum of manpower. Production and assembly methods should be sought that use already available equipment and which give the highest production per man-hour of labor involved. Unnecessary and labor-wasting quality, accessories or finishes should not be specified (and if specified by the contracting service, they should be courageously protested). Present operating equipment should be made as mechanized and as "labor-saving" as it is possible for us to make it.

Manpower efficiently used at home now will mean manpower saved at the front later. And that means something personal to practically every one of us!

FRED P. PETERS

A Methods Article Broaching is one of the machining processes that has made great progress in the war years. The Springfield Armory, for example, has done outstanding work in using this method for rifling machine gun and rifle barrels, with production increased several times thereby. Mr. Cady describes the process as used at Springfield, with emphasis on the engineering problems that have already been solved and especially on those whose solution, yet to come, will be followed by a remarkable expansion in use of broaching

Each button is checked optically and by dial gage.

Broaching of Machine Gun Barrels

by EDWIN LAIRD CADY

At Springfield Arsenal, Springfield, Mass., the internal broaching of machine gun and rifle barrels is saving time and conserving floor space. Furthermore it is reducing spoilage and rejections almost to the vanishing point; a very important advantage since rifling is the last major production operation to be performed on gun barrels.

But although it is successful, this broaching has barely passed its initial development stage. Serious problems remain; problems which when solved may open entirely new fields to deep hole and helix broaching.

The saving of time as compared to previous methods is unusual. Broaching is done in two passes, the first using a roughing broach and the other a finishing broach. Allowed time is 1 min. and 33 sec. per operation or a total of 3 min. and 3 sec. a barrel or slightly less than 20 barrels an hour. This compares

with 3.2 barrels an hour by the hook tool method which broaching is displacing. (A hook tool is a single button, two way cutting broach.)

The operating cycle time can be reduced still further by magazine feeds, better materials handling methods, automatic indexing and the like. Right now the operators like to make the roughing cut on the barrel, inspect it, and then run the finishing broach through, thus keeping an independent check on the performance of each broach. If this were not done, any tearing of the work, eccentricity or other faultiness would require trials of both broaches to find out which one was out of order. All of this handling of the barrels, plus inserting the broaches by hand, uses up some 78 sec. of the 93-sec. broaching cycle—the actual cutting time per broach is only about 15 sec. The 78 sec. period is open to attack by the tools and materials handling methods common to the operation of machine tools.

One of the reasons for continuing the hand handling methods until the whole operation approaches its final stages of perfection is the demand for complete accuracy with perfect surface finish within the barrels. Right now the work spoilage has been reduced to some 2 barrels out of every 900 broached; this amounts to some 0.20% as compared to 3 to 4% of spoilage by the hook cutter method. And furthermore there are fewer barrels on the borderline between acceptance and rejection, fewer cases in which the "go" gage just barely will go or the "no go" just barely will not go, almost no examples of the bell mouth or choke mouth which the 30 passes of the jook tool were so likely to produce. But the surface finish is too likely to contain chatter patterns which give optical illusions of faultiness, and these illusions might bother the soldier who was making sure he kept his barrel clean. These chatter marks are the problems which the production men have under immediate attack.

Generating The Helix

Chatter troubles are common to broaching as to any form tool cutting. And in this operation there is an unusual tendency toward them since the very thin broach must bear the torque load of generating the helix inside the barrel as well as the axial load of cutting the metal. Furthermore the peripheries of the broach buttons must be interrupted by deep grooves so the broach can form the lands while finishing the barrel; therefore the rigidity or support against chatter cannot be that which would be obtained from an uninterrupted circle but must be that which the shaft and the inner sections of the buttons can afford in spite of the leverages of the button peripheries against those inner sections.

In the original or experimental method of generating the helix, the broach is pulled by a lead bar (lead screw) which turns the broach at the exact rate necessary. Naturally, the broach tends to resist this twisting, since force always likes to travel in a straight line and always hates to turn a corner. Between the broach and the lead bar is a long, thin bar, long and thin enough to reach through the barrel so the broach may be attached. The full length of this straight bar is available to amplify any vibrations set up by the broach; the bar has a torque load from transmitting the twist from the lead bar to the broach and this torque by itself could set up vibrations; all the vibrations can appear as chatter marks within the barrel.

An advanced method is to turn the first button of the broach to an angle which will cause its natural motion to generate the helix; the succeeding buttons then having a tendency to follow the path produced by the first one.

The helix is 15 in., or one complete revolution for each 15 in. of barrel length. The first button therefore was set at that angle. To prevent any opposition between the lead bar helix and that generated by the broach itself, the lead bar is removed. The broach then is attached to the puller by a ball bearing head, the ball bearings removing all friction and all torque opposition between the broach and its puller and therefore permitting the broach to follow its own path without any of the vibrations which would be induced by applying torque to the broach by devices external to itself. The first button thus generates the helix.

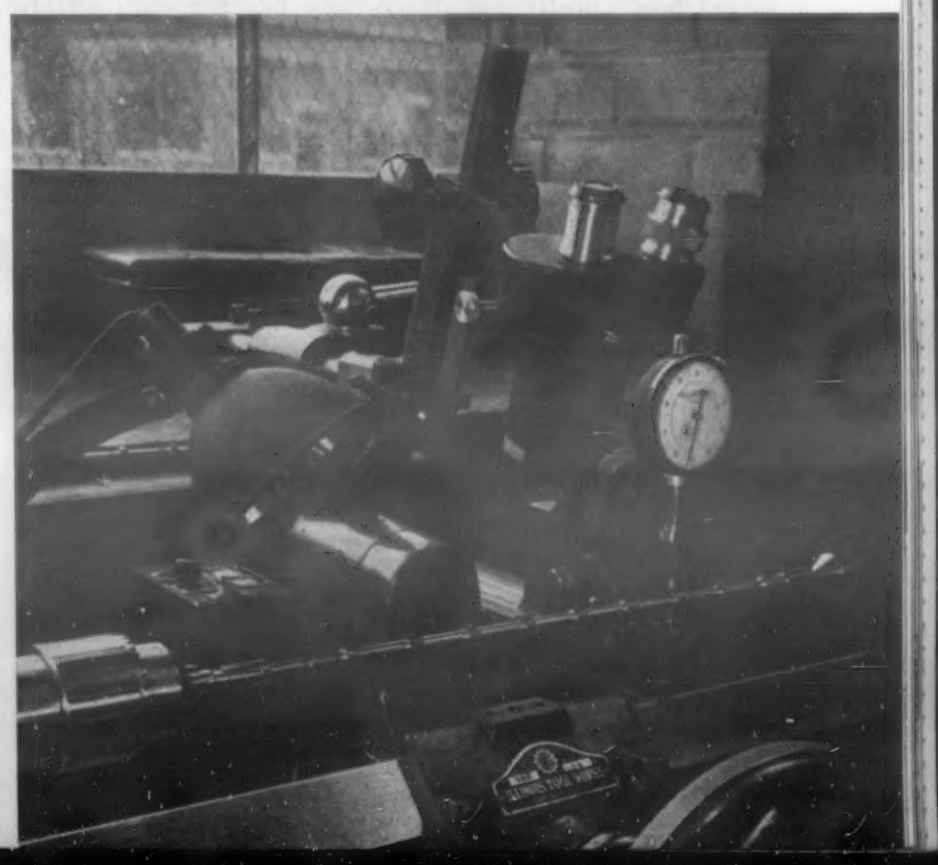
This procedure did not sufficiently remove the tendency of the broach to fight its twisting motion. As an experiment, the leading button was set at a 14.5-in. helix. The broach then continued to generate the desired 15-in. helix, and with far less chatter.

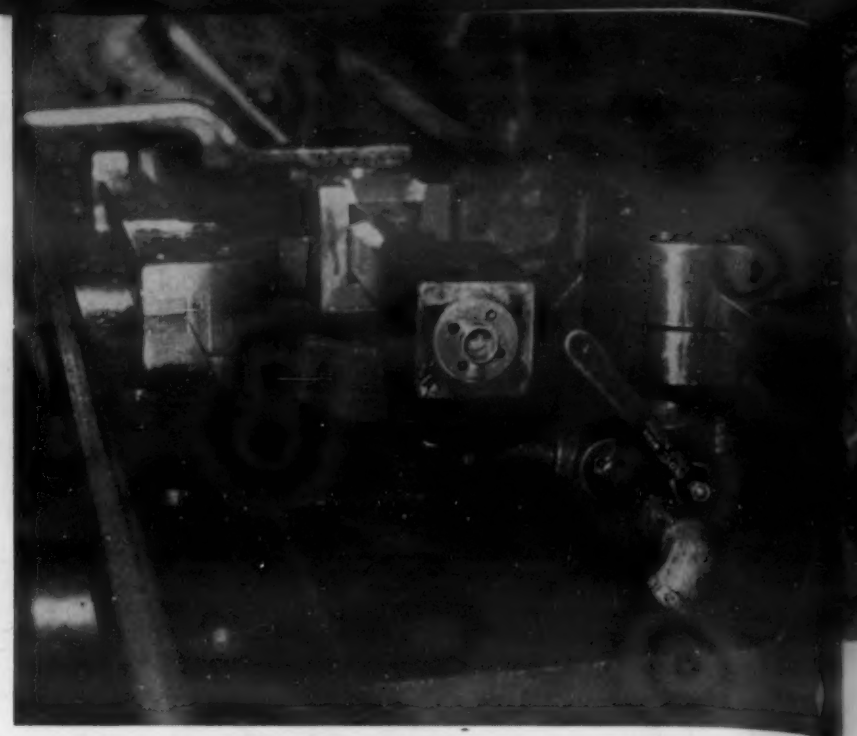
The generating of the helix having thus been assigned to the first button, that button was relieved of some of its other functions. Its corners were removed so its periphery did not cut the full width between the barrel lands—the narrower the periphery of each cutting section of this button, the less the resistance to the twisting motion necessary to generate the helix.

This narrowness was helped by the chip breaker. The first button originally had had one chip breaker, the second button had two of them, the third had one, and so on alternately until the last or finishing buttons which had no chip breakers at all.

This practice was continued. As a result, the cutting periphery of the first button was only that which was left between the relieved corners and the chip

Another view of the button-inspecting set-up.





New ball check device, disassembled and assembled. This permits cutting oil to be fed from behind broach throughout broach tr

breaker, this button therefore had solid support or high rigidity from its middle sections and was not likely to set up any chatter which would be amplified at the following buttons. By these changes in the first button the chatter problem was vastly reduced. But it was not eliminated.

Button Sizes and Number

In the early days before the corners on the first button were relieved, all buttons had approximately equal cutting peripheries and finding the correct outside diameters or "sizes" of the buttons was the usual simple matter of dividing among the buttons the amount of metal to be removed and increasing the size of each succeeding one accordingly.

But with the periphery of the first button narrowed, the succeeding buttons had to take on the burden of cutting the grooves to full widths between lands as well as of cutting at their peripheries.

As an experiment, the second button was made 0.0003 to 0.0004 in. less in diameter than the first one, but wide enough to cut the full width. The second button thus was cutting no metal at all at the parts of its periphery immediately below the path cut by the periphery of the first button. And this resulted in chatter.

In a second experiment, the diameter of the second button was made the same as that of the first one. The second button still was cutting only—or at least mostly—at its corners, but the path left by the periphery of the first button was acting as a guide to prevent radial or sidewise motion of the second button. This practice resulted in reduction of chatter, and was continued. Amounts of metal to be removed by succeeding buttons then were divided among them in the regular manner. The net result was that each button removes an equal amount of metal, although the first button still has the generating of the helix as its main duty.

Experience proved that some of the chatter, plus some tearing of the metal and some troubles with chips welding to the cutting edges, could be caused by each button having too little metal to remove. In fact, when final finishing buttons were tried which removed no stock at all but merely took off burrs and "smoothed up" the job, the metal removed from those buttons by the lands was at least equal to the metal removed from the lands by the buttons and the resultant wear on those buttons made whole broaches useless so rapidly that the practice had to be discontinued.

Original broaches had 10 buttons and each button had about 0.0004 in. of metal per side to remove. This was not enough for the cutting edge to get "under the skin" of the metal.

Later broaches had 9 buttons, and each button removed 0.0005 in. per side. This worked much better. But the latest experimental broaches have 7 buttons and each button removes 0.0007 in. per side. The final verdict has not been rendered, but these 7 button broaches promise to produce enough better finishes so they will displace the 9 button ones.

Other Attacks on Chattering

Wear on the periphery of a button appears as a white line, visible to the naked eye, along the cutting edge. Grinding the face back enough to remove this line, means removing about 0.002 in. of stock, and with the 3 deg. relief angle this results in a decrease of about 0.0001 in. on the outside diameter. A typical button when new has an outside diameter of 0.5109 in., it can be reground until it is 0.5096 in., and this leaves 0.0013 in. which can be removed before the broach becomes too small for further use. In actual practice a broach usually can be reground 7 or 8 times, will produce 100 to 125 barrels per grind, and thus has a production life of from 700 to 1000 barrels.

In an attempt to prolong this life, grinding away only part of the white line of wear was tried. This had the unexpected result of reducing chatter. Just how this will work out as a formal practice, or whether it will be advisable to produce an area on new broaches similar to that "white line of wear," is not known at present. Experiments with it are just beginning.

As is common experience with chatter problems, this shop found that some individual broaches would work out their service lives with almost no chatter at all, while others would chatter almost from the start. The usual course was followed of checking the non-chattering ones against the chattering ones to see what the differences might be. One broach which

Broach regrinding is done in sound proofed, vibration proofed room.

hardly chattered at all, was found to have its first three buttons unevenly spaced apart. As an experiment, broaches were made with the second button 1 9/32 in. from the first, the third button 1 7/32 in. from the second, and the others the usual 1½ in. apart. This reduced the chatter, and therefore uneven spacings of various buttons and of all the buttons were tried.

Best results were obtained by uneven spacing of the first two and of the last two buttons, with the others all evenly spaced. Such changing of the button spacings tends to cause the ends of the broach to vibrate at different sonic frequencies than the middle. Thus vibrations set up at either end are dampened at the middle, those set up at the middle are dampened at the ends, and the entire broach resists any vibrations which might be set up by machine members other than itself.

Speeds, Cutting Oil and Pressures

Speed at which the broach traveled was found to be important to the type of finish obtained. And this speed has to be varied somewhat with the hardness of the stock being cut.

On stock of 25 Rockwell C hardness (used in the barrels of side arms) bad tearing was encountered at any broach speed of less than 30 fpm. On 27 to 29 Rockwell C hardness stock which is used in the machine gun barrels, speeds of 16 to 20 fpm are better; any speed lower than this produces tears while anything higher is likely to leave undesirable streaked effects.

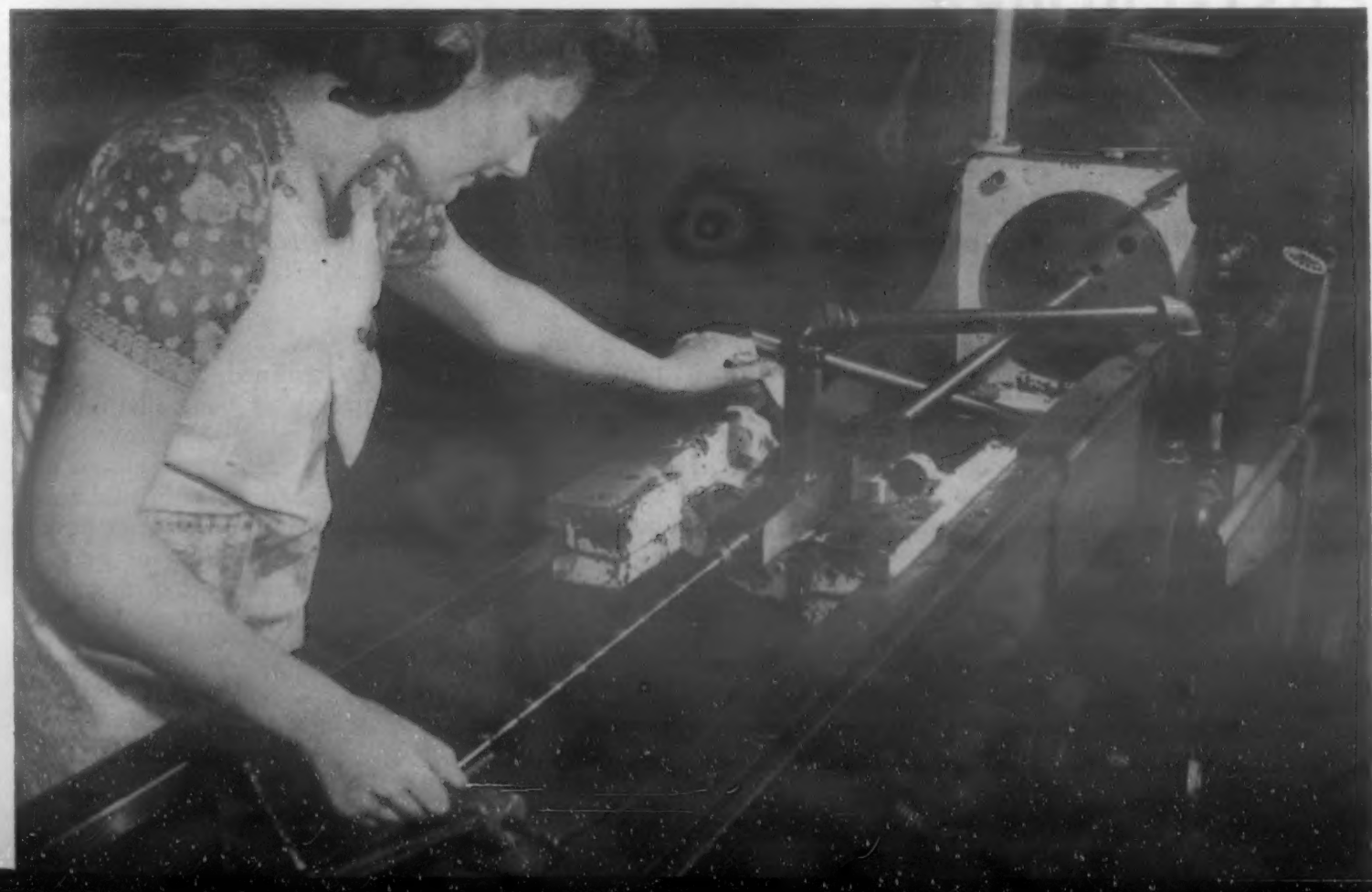
Cutting oil has to be extremely high in lubricity and yet have that tendency to produce fine finishes which is commonly found in lard oils. Heavy duty lard oil with sulphur added is used. At room temperature this oil would be far too heavy for the spaces through which it must pass, therefore it is heated to 150 F.

High pressure of the cutting oil is used to prevent chips from welding to cutting edges. This pressure originally was 450 p.s.i. but now has been stepped up to 900 p.s.i. with no apparent effect upon the work.

Cutting oil pressure, then, is one more experiment which is being tried in an effort to achieve perfection. Another is the direction of feed of the oil. At present this feed is to the side of the broach through part of the broach travel, and although there seems to be no physical reason why the pressure should not equalize itself about the broach, a set up is being tried which will feed the oil from directly behind the broach at all portions of the broach travel.

It should be emphasized that very rarely has this broaching process produced barrels which would not fire perfectly in battle and that no such defective barrels have escaped the inspectors. The production men at Springfield Arsenal are working toward a perfection which will be far beyond mere mechanical adequacy. And in doing so, they are working out methods and "kinks" which will be of great advantage to the metal working industry.

Inserting a broach. Cutting oil pipe feeds to top side of broach through part of broach travel.



A Materials Article Metal stampings have a new competitor and the plastics materials a new forming technique in laminated phenolic shapes that have been bent or drawn after curing or heat-setting. In this article Mr. Sullivan describes this "post-forming" process and the properties of the resulting material.

Among this group of post-formed plastic parts are some that require simply bending and others involving a substantial amount of drawing.

Post-Formed Laminated Phenolic Plastics

by **FRANK SULLIVAN** *Engineering Department, The Formica Insulation Co., Cincinnati, Ohio*

SEVERAL MANUFACTURERS of laminated plastic sheet material are now marketing a special laminated forming sheet. This sheet is meeting the requirements of a material that can be drawn or shaped inexpensively into articles which in the past have been made of metal or have been molded from plastic molding materials. Similar to most new materials, it has likewise made possible many new applications built around its own peculiar and distinct properties, which will be outlined below.

The term of post-forming is generally used to designate the procedure by which this material is formed after the laminations have been heat-set. It is simply the reshaping of a cured laminated sheet. Forming is accomplished by heating the sheet rapidly to a high temperature, quickly bending or drawing it into the new contour and holding it in this shape until it has cooled.

The Material and Process

Thermoset phenolic resin sheets, which have been laminated, are used. They retain a degree of the thermoplastic quality, which gives the necessary formability. To make use of this quality the piece to be formed is heated quickly. It is important that the piece be brought to temperature quickly for further polymerization or setting will occur with heat and time. Naturally, the higher the temperature, the more plastic the piece will become, the limiting temperature being that at which the sheet blisters.

Isolated cases of bending with thermoplastic sheet have been done in the past. Thus, phenolic sheets have been heated and bent, and urea laminates have been soaked in warm water and bent, but the conditions necessary to fully develop bending possibilities had not previously been understood. It remained for William Beach of North American Aviation to realize the possibilities and to develop the new high-temperature technique.

The material used has been a special grade of phenolic resin-laminated canvas. What happens is this: The high temperature exposure causes the sheet to soften before the chemical action of hardening has set in. This chemical action takes time. If the sheet is formed rapidly, the polymerization is slight before the laminate has taken its new shape. Once heated, the sheet loses some of its forming character.

Forming sheet is being produced which has the characteristics of regular standard Grade C. It has not been necessary to detract from the normally good qualities to produce forming properties. Forming sheet is furnished in standard sizes up to 36 in. x 96 in. The most common thickness is 1/16 in.

The technique used in forming this material, while quite different from the forming of sheet metal or the molding of plastic shapes, is simple to perform and readily adaptable to a wide variation of production conditions. Four steps are necessary to transfer the forming sheet to the finished article. These are:

1. Cutting to shape.
2. Heating the material to formable condition.
3. Shaping.
4. Cooling.

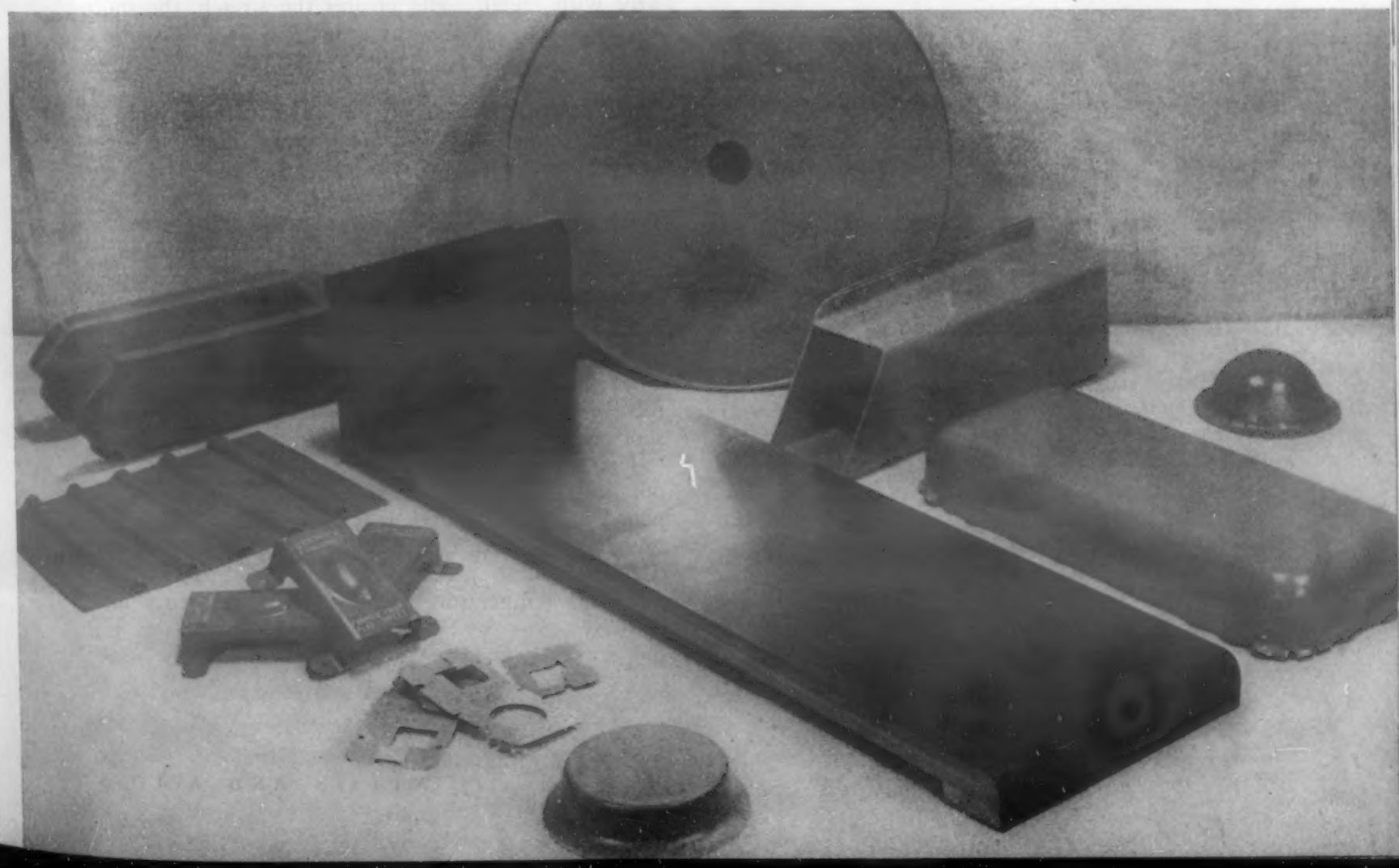
The equipment and skill required to cut the desired shape of the article before it is formed from a flat sheet will depend upon the article itself. In many cases when strips are to be bent, the material may be sheared or sawed to the size required, shearing or sawing several sheets simultaneously. In large production jobs, where the number of pieces may run into thousands, blanking dies of steel or Kirksite may be used provided the size required is not too great. Where large pieces of intricate pattern are needed routing machines, such as are used for cutting aluminum alloy sheet, are usually most satisfactory.

Heating to a Formable Condition

To a great extent the success or failure in forming depends upon the ability of the operator to judge correctly the time of heating in the oven. If the material is left in the oven too long, blistering will occur and should the piece be removed too soon it will crack when formed. To be able to remove the piece from the oven and transfer it to the forming jig to get a satisfactory product requires some knowledge of the working properties of the material and some actual practice in forming.

By actual measurement of the temperatures of the material, using thermocouples imbedded between the laminations, it is possible to determine the tempera-

A group of post-formed parts, with a straight-bending form in the middle. Note the shape and design resemblance of many of these parts to metal stampings.



tures for the ultimate forming conditions. As the sheet is heated by application of heat from the outside, there will always be a differential from the outside to the center of the sheet. In very thin sheets this will be small, but for sheets up to ⅜ in. this differential may amount to as much as 35 to 55 degrees F.

Disregarding this differential for the present, we find that when the temperature of the sheet reaches 250 F, it begins to soften slightly and continues to soften and become more pliable until it reaches 350-355 F, where it blisters. Very little ability to form exists when the temperature is at 250 F but this forming ability increases rapidly until the blistering point is reached.

A typical post-forming setup—bending-block, laminated sheet attached to punch, and the formed part.

To form successfully, then it is evident that the operator must work with the temperature of the material as close to the blistering point as possible. Considering the differential that will exist between the center of the sheet and the surface, *the temperature of the heating medium must be adjusted so that the center will be as hot as it is possible to get it without overheating the material near the surface.*

Time of heating must also be considered, because if the temperature of the material is raised slowly it will become somewhat dry and brittle and the formability will be decreased considerably. Considering the element of time we may now rewrite the italicized statement above to read: *The temperature of the heating medium must be such that the center of the sheet must be brought to forming condition as quickly as it is possible to do so without blistering the surface material.*

Compared with molded laminates the accuracy of post-formed sheet parts is not as great. Close dimensions are harder to hold. For forming the thickness is essentially uniform throughout. Stretched sections vary only slightly in thickness. Square outside corners cannot be made. On the other hand the forming method has simplicity and adaptability and for some shapes is definitely less expensive.

Special Grade C canvas-base phenolic sheet is used almost exclusively. The drawing of complex shapes causes the threads of the canvas to straighten out, to crimp, or to bias. For example, when a cup is drawn, the threads at the bottom are stretched, those around the circumference are compressed, and those at 45° angle with the drawing direction are drawn into a shape. This latter phenomenon can be seen by stretching bias tape.

The threads maintain their original identity and do not break, and the final piece has the general character of the original sheet. Because it is the threads which do the forming, paper base stock is still a problem. Percent of strength in a good laminated sheet may be as much as 12% in the direction of the threads and 30% along the diagonal. Hence, if extreme bends are desired, they should be diagonal to the threads.

A real advantage comes from the fact that the stretch comes by uncrimping the threads. This fact prevents local thin spots such as are encountered with unfilled thermoplastic sheet, and also to a lesser degree with metal. The greater the stretch, the more the resistance; hence, the stretch tends to distribute itself uniformly.

In practice it has been found that it is easier to draw this plastic than it is to draw a similar piece of metal. Metal often requires several drawing steps, whereas the laminate requires only one. The combined material and labor cost to produce a formed piece is cheaper for the laminate than for metal.

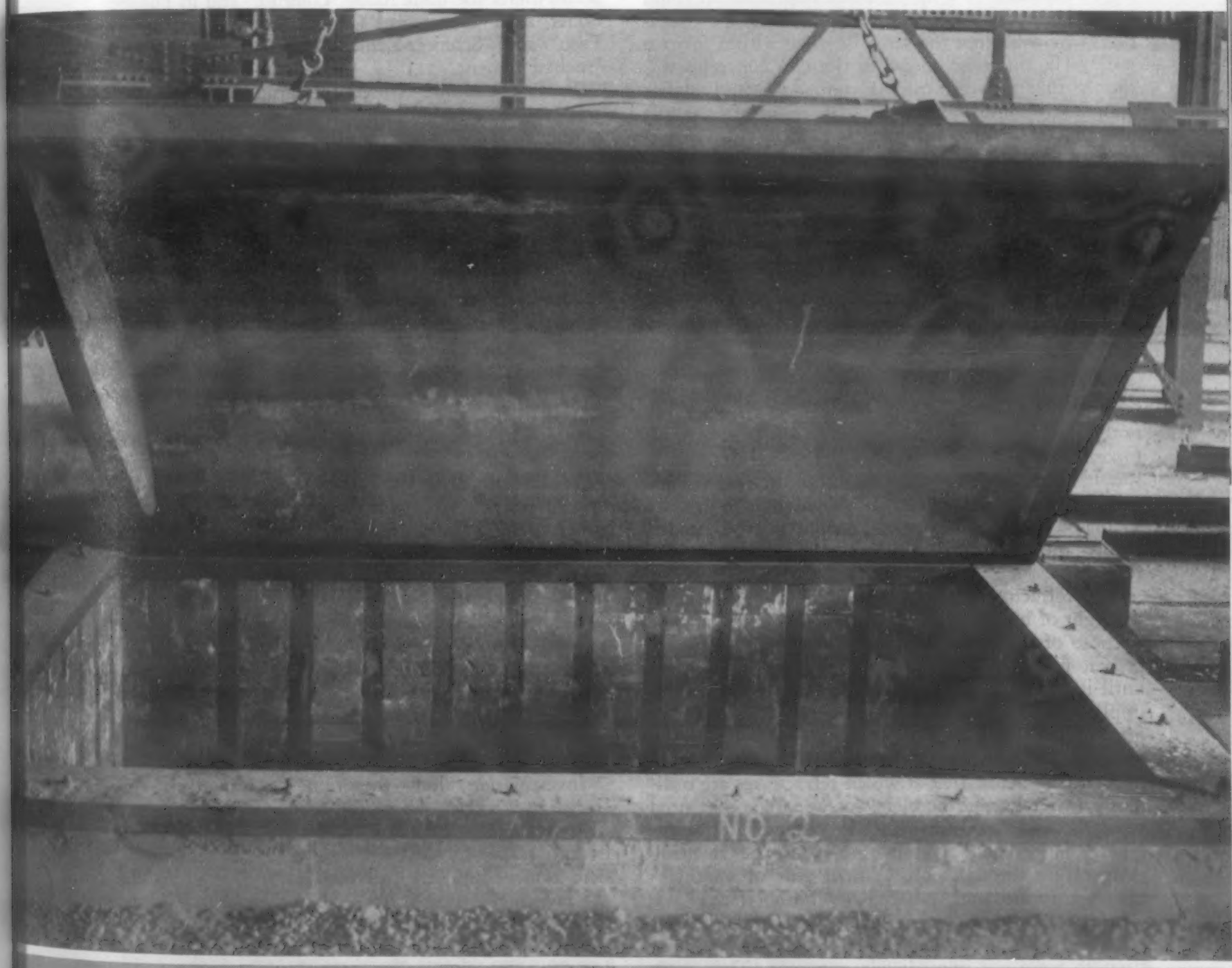
There are several other fundamental advantages over metal. The vibration absorption characteristics of the plastic have always been one of its greatest advantages. The laminate is one-half as heavy as aluminum and it is much more chemically resistant. The abrasion resistance is better than the softer metals. It will not tend to flower or petal out when shot through to the same extent as will metal.

Finally, there is one further advantage which has not been given sufficient emphasis in the past: the plastic will not dent, whereas a metal which will form can also be dented. Here the forming or denting character is only present while the piece is very hot. At room temperature the sheet has resiliency and stiffness.

Refractory Concrete for Furnace Construction

by **GERALD T. HADDOCK** *The Atlas Lumnite Cement Co., New York*

Slow-cooling pit for billets. Refractory concrete walls are armored with T-rails. Refractory insulating concrete was used for cover lining for light-weight and heat retention.



A Materials-and-Methods Article Engineers responsible for the selection, design, installation or operation of industrial furnaces will welcome this up-to-date review of the characteristics, uses and methods-of-applying refractory concrete—a group of special refractory materials that can be poured in place to give intricate, joint-free, high-temperature (or insulating) furnace structures of a wide variety of types.

THE DEVELOPMENT OF THE USE of refractory concrete in the construction of furnaces and industrial structures exposed to heat is in some respects similar to the rapid extension of the use of ordinary concrete in building construction. Indeed, many of the advantages of structural concrete are of equal or greater importance in refractory concrete installations. For example: elimination of joints, ability to cast intricate units in place, freedom in selection of size and shape of sections, may each be a determining factor in choosing concrete for buildings or refractory concrete for furnaces.

Speed of construction is another factor common to the two types of concrete. With each, the essential building material—concrete—is made on the job during the process of erection; the complications and delay involved in ordering a variety of kinds, shapes and sizes of materials are eliminated.

As the advantages of the concrete principle of construction became apparent, men working with refractories sought to adapt this principle to the building of furnaces. If a finished building material could be made on the job, made and placed in one operation, why could not the same be done with a furnace wall? The difference between the two concretes was simply that the refractory had to withstand higher temperatures and more severe conditions after it was in place. But this difference was not entirely unfavorable to refractory concrete. The service conditions were not unlike those under which refractories were made. Instead of pre-firing small units, why not fire the whole structure in place after building?

These considerations led to two approaches to the problem of refractory concrete. From the viewpoint of men experienced in cement work the answer was simple, although at the time the goal seemed unattainable. It was necessary to have a cold-setting cement which did not disintegrate when subject to prolonged heating at elevated temperatures. Preferably it should be a hydrating cement, one that sets when mixed with water. The setting action of the cement should not depend on exposure to air, nor on the application of artificial heat. It should harden rapidly so that a long curing period would not be needed before the refractory concrete could be placed in service.

The refractories engineer viewed the problem in the light of his knowledge of refractory binders. The purpose of the binder was to hold the raw mass together, to give it the necessary structural strength, until it was heated and acquired fired strength. This implied the use of aggregates which would yield high fired-strength at comparatively low temperatures, because the service temperatures of the furnaces would generally be below that at which refractories are ordinarily fired. Furthermore, it was apparent that fired strength alone was not sufficient because a wall exposed to heat on only one side would be at firing temperature through only a small part of its thickness, *i.e.,* immediately adjacent to the hot face.

After a suitable cement had been found, the implications of combining hydraulic strength and fired strength were not immediately apparent. They were soon recognized, however, when it became possible to observe pieces of refractory concrete which had been in service. The characteristic colors of different strata in pieces of concrete taken from furnace walls gave a rough check on the changes which had taken place. This made it easy to study a large number of installations with a minimum of time-consuming laboratory work.

Calcium-Aluminate Cement

The development of refractory concrete began when cement of the calcium-aluminate type was tried as a binder. Calcium-aluminate cement had been developed in Europe and America to meet the demand for structural concrete having certain special properties, primarily resistance to corrosion and high strength at 24 hr. Such a cement had been made and used during World War I for the rapid construction of gun emplacements on the western front. During the 1920's it was being manufactured in the United States under the trade name "Lumnite" and in Europe under such names as "Ciment Fondu," "Cimento Fuso" and "Schmelz-Zement," all meaning literally "melted cement."

Because Lumnite is used for rapid-hardening concrete some confusion has arisen between the calcium-aluminate cements and the high-early-strength portland cements which were introduced several years later. A calcium-aluminate cement is not a portland cement. It is made from different raw materials, its chemical composition and physical characteristics are different. Consequently the products of hydration of the two types of cement are different. The properties of the hydrated cement affect the properties of the concrete.

Refractory Concrete and Calcium-Aluminate Cement

When the new calcium-aluminate cement was found to have characteristics distinctly different from those of all other available cements, the manufacturers undertook to determine its suitability for many special purposes. Among these was the making of concrete for continued exposure to high temperatures. At the same time, makers of refractories, who had tried all sorts of hydrating cements in efforts to produce satisfactory cold-setting castable refractories, found that calcium-aluminate cement would do the job. A study of the difference between calcium-aluminate and portland cements as related to structural fire-proofing was made by Prof. A. L. Miller of the University of Washington in 1927. Results were published in Bulletin No. 43 of the U. of W. Engineering Experiment Station in September, 1927.

Investigation along these lines was actively followed in America where the principles and practice of making refractory concrete were developed. However, a refractory cement made with calcium-aluminate cement and calcined bauxite was described by the French engineer, J. Arnould, in a paper in "Chimie et Industrie" in 1926. Arnould suggested the use of this refractory cement with crushed firebrick for making concrete.

After limited use in the later 1920's, the lean years following 1929 gave an opportunity for extensive experimental work of a practical nature in industrial plants. Most of this work was made possible by the fact that refractory concrete offered a means of salvaging used firebrick and refractory shapes, large quantities of which had accumulated in the more active years. Plant operators were willing to try refractory concrete because of the economies resulting from the use of salvaged material. There was an immediate saving regardless of what the future might show on service life and cost.

The records of service and cost developed in those years were such that the use of refractory concrete forged rapidly ahead after industrial activity picked up in 1936. When the defense program got under way, refractory concrete took another leap forward because of its contribution to speed of construction and facility of maintenance. The ever-increasing scope of refractory concrete installations has provided opportunity for study of the material under a large variety of service conditions. At the same time systematic laboratory investigations have been carried on.

How Refractory Concrete is Made

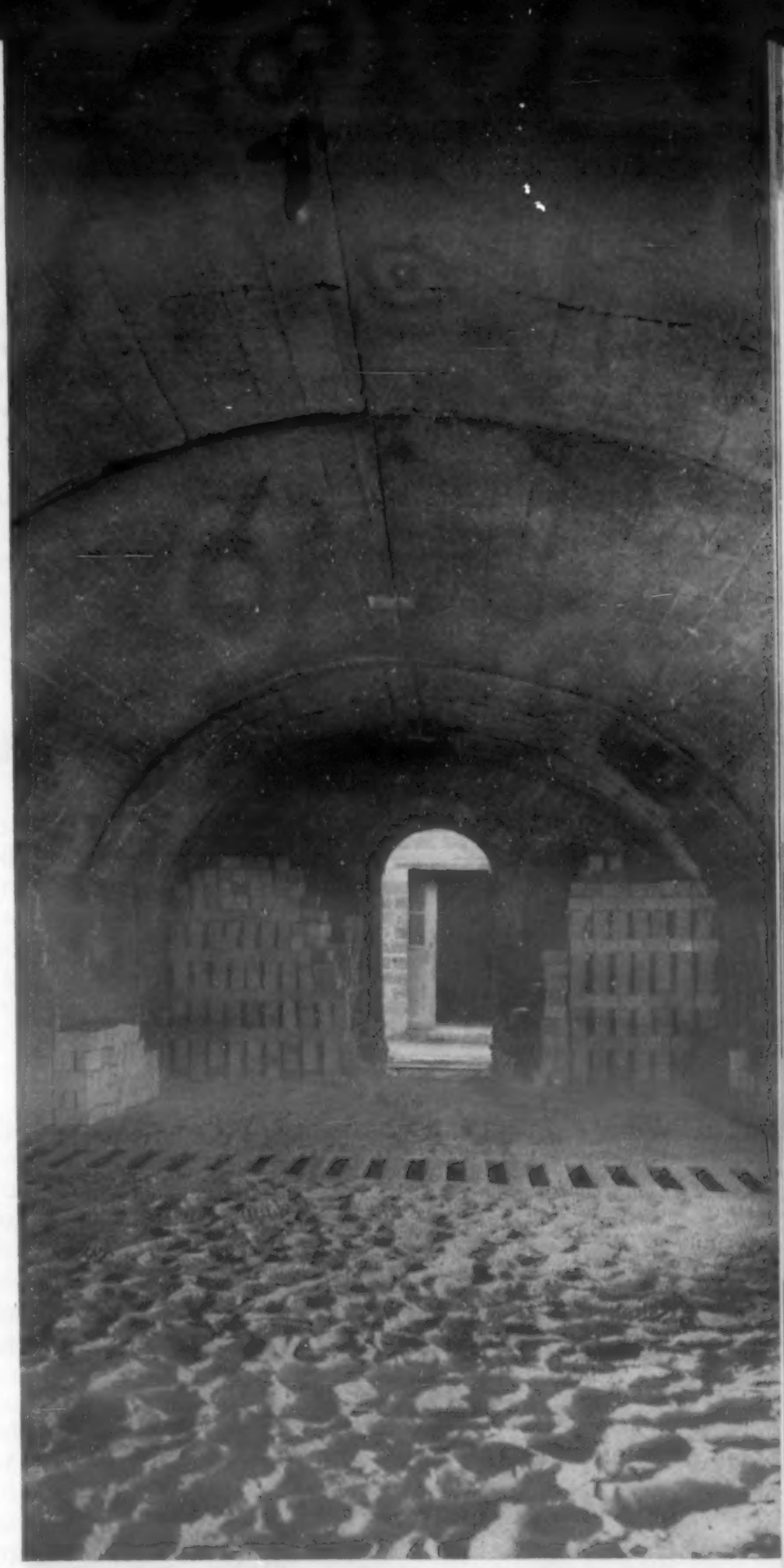
The general term "Refractory Concrete" has been used somewhat loosely in this paper to cover all concrete suitable for temperatures higher than 500 F, which is commonly accepted as the upper limit for portland-cement concrete. A distinction is ordinarily made between heat-resistant concrete and refractory concrete. The former designates concrete for service above 500 F but below the temperature at which fired strength is attained. For practical purposes, the limit for heat-resistant concrete can be assumed to be about 1400 F. Another distinction is made between refractory concrete and refractory insulating concrete. The latter is concrete suitable for temperatures above 1400 F and which has thermal conductivity appreciably lower than firebrick or concrete made with firebrick aggregate.

Before describing specific applications of refractory concrete, it will be helpful to consider briefly the principles of making the concrete and the characteristics of the concrete in service. Any concrete is essentially a mass of inert aggregates held together by a binder which sets and hardens by chemical action after the plastic mass is in place. In ordinary structural concrete such aggregates as sand, gravel and crushed stone are used; the binder is portland cement and the setting action is due to the hydration of the cement.

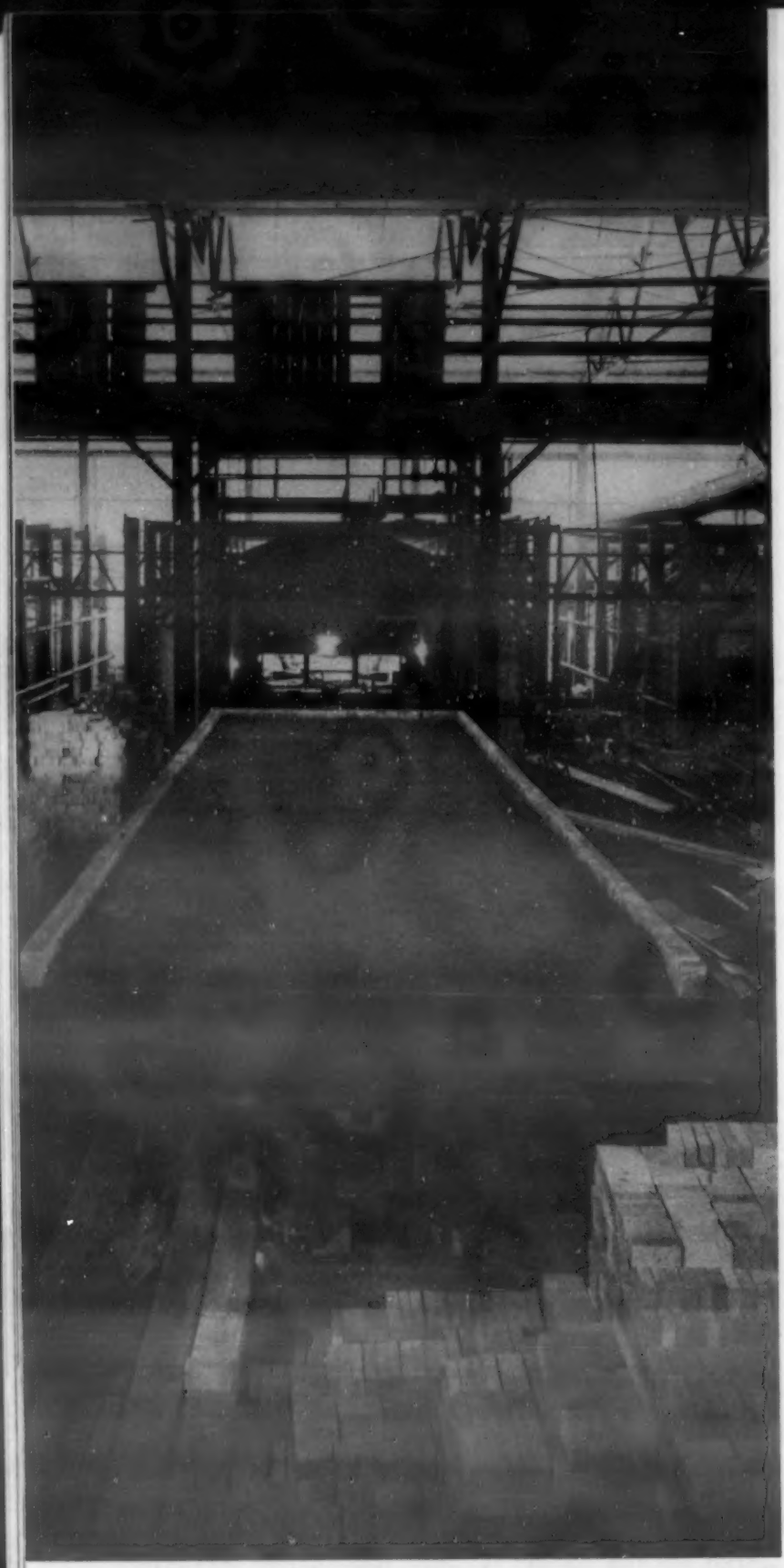
In refractory concrete the aggregates must be refractory materials or materials which at service temperatures do not disintegrate and which—at the higher temperatures—react with the cement to form physically stable compounds. The calcium-aluminate cement used as a binder sets and gains cold-strength through hydration, fired strength is built up through the reaction of the hydrated calcium-aluminate compounds and the fine particles of the aggregate.

Crushed clay-firebrick, or "'grog," is the most common aggregate for refractory concrete. Used firebrick are reduced to aggregate size by crushing in a jaw crusher, dry-pan or other convenient device. Before crushing, it is necessary to remove any silica brick and common building brick which may be in the pile. The brick are cleaned of adhering mortar, refractory cement or plaster. The grading of the crushed aggregate is important, the percentage of fines must be much higher than that in aggregate for structural concrete. Fortunately, the nature of firebrick is such that a relatively high percentage of fines generally results from crushing, but it may be necessary to add extra fines or a small proportion of plastic fireclay.

Salvaged firebrick is an important source of aggregate for refractory concrete but by no means the only economical material. Fireclay shapes may, of course,



Refractory concrete roof arch with 14-ft. span. This sprung arch in a periodic kiln is 37 ft. long. The joints are the two across the arch at the third points and one longitudinally at the crown.



9-in. insulating concrete slab for car top of heat-treating furnace, 42 ft. 7 in. long 15 ft. wide. The slab will be covered with a 4½-in. brick wearing surface.

be used as well as brick. Fireclay grog is produced by manufacturers of refractory products and sold either as aggregate or premixed with Lumnite in the products known commercially as "Castable Refractories." Although maximum economy results from the use of salvaged refractories, refractory concrete made with purchased aggregate is generally low in cost in comparison with other refractory materials.

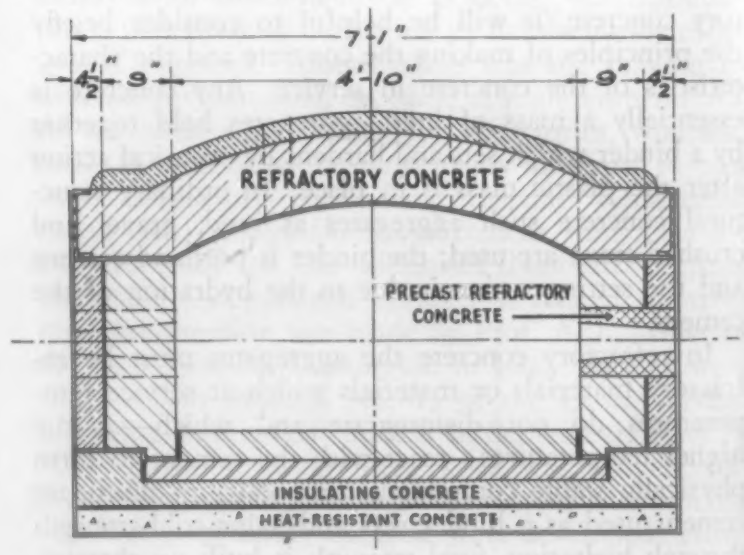
As in all concrete work, the cement, aggregate, and water are mixed together and cast in forms or molds. But the proportions of aggregate and cement are quite different from those of structural concrete. Refractory concrete must gain strength quickly. The rapid-hardening property of calcium-aluminate cement is of the first importance because it would be impractical in furnace construction to wait days or weeks for the concrete to reach adequate cold-strength.

Another difference in concrete practice is in the quantity of water used in mixing and curing. Refractory aggregates such as crushed firebrick are highly absorptive, so that a much larger quantity of water is needed in order to obtain a plastic mix than is the case with structural concrete. On the other hand, less water is needed for curing as the water absorbed by the aggregate seems to be effective during the curing period. Nevertheless, it is desirable to sprinkle refractory concrete and keep the surfaces wet for several hours after final set has occurred.

Characteristics of Refractory Concrete

It will be seen that in spite of differences in aggregate, proportions, and curing, the procedure in building with refractory concrete is fundamentally the same as that followed in ordinary concrete construction. In service, however, refractory concrete performs in a distinctly different manner. The portland cement industry has rightly emphasized the slogan "Concrete for Permanence." But refractories are not permanent, they are consumed in service. The economy of a refractory is a function of its initial cost, its influence on operating expense and its length of life. With the refractory concrete in place, ready for service, we must lay aside the analogy with structural concrete and consider the changes which take place in the state of the refractory concrete during its service life.

Heat-resistant and refractory concrete gain high cold strength within 24 hr. They contain a considerable quantity of free water—the excess mixing water which has not combined with the Lumnite.

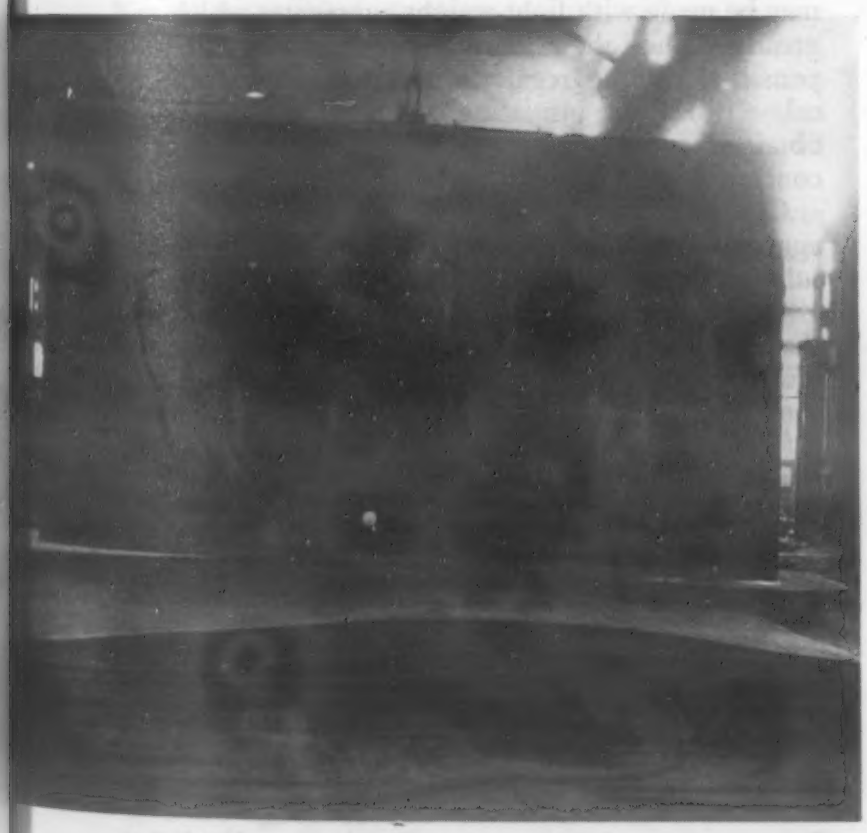


Construction detail of rivet-rod heating furnace. The three types of concrete are made with calcium-aluminate cement and different kinds of aggregate.

This water is driven off by an initial period of slow heating. The concrete is then brought up to service temperature. With continued exposure to elevated temperature there is a drop in the strength of the concrete. If the concrete is heated on all sides, so that uniform temperature prevails throughout the mass, the strength of the entire unit is reduced.

In most installations, as in furnace walls and arches, the concrete is heated only on one side. The reduction in strength at any point in the section depends on the temperature at that point. Therefore, a heat-resistant concrete wall with constant high temperature on only one side has relatively high cold-strength on the cold face diminishing to a lower strength on the hot face where it has partially dehydrated.

At higher temperatures the fired strength of refractory concrete is built up by the vitrification of the aggregate and by the reaction of the fine aggregate and the Lumnite. This secondary binding action may be described as the formation of a "Ceramic Bond." With the aggregates now in general use for ordinary refractory concrete the development of fired strength begins at about 1500 F. The typical refractory concrete wall heated on only one side has high cold strength (hydraulic) on the cold face, a zone of lower strength (partially dehydrated) somewhere within the section, and fired strength at or near the hot face. At a service temperature around the softening point of the aggregate the actual hot face of the refractory concrete may have no effective strength, but the immediately adjacent portion will have fired strength.



Monolithic door lining of refractory insulating concrete for a heat-treating furnace. The lining is 9 ft. 6 in. high, 16 ft. 4 in. wide.

An explanation of the strength characteristics of heated refractory concrete is essential to an understanding of methods of designing furnaces for construction with this material. The explanation defines the limitations of the material and points the way for future development work. For practical purposes it is only necessary to remember that: (1) The effective strength of a refractory concrete wall is the total strength across the section; (2) the plane of low strength depends on the temperature gradient through the section; (3) the fired strength depends on the nature of the aggregate, proportions of mix and service temperature; and (4) the strength after heating is less than original cold-strength of the concrete.

Varieties of High-Temperature Concrete

The discussion of the characteristics of refractory concrete has referred only to concrete made with calcium-aluminate cement and crushed firebrick or similar fireclay grog. The same principles apply in general to high-temperature concrete made with calcium-aluminate cement and other aggregates, whether the concrete be classed as heat-resistant, refractory, or insulating. It will be helpful to distinguish each of these three both as to composition and physical properties.

Heat-Resistant Concrete: Concrete men who hear about the use of Lumnite for high-temperature work sometimes think that all they have to do is to use Lumnite in place of portland cement when they want concrete which will resist heat. It is not as simple as that. Cement is only one of the ingredients of concrete and no concrete is more durable than its weakest aggregate. For heat-resistant concrete the aggregate must be of a kind which does not disintegrate in the course of long exposure to soaking heat, and it must not undergo sudden volume change when heated. The first limitation rules out limestone or any calcareous aggregate, the second eliminates siliceous sand and gravel. These aggregates, ordinarily used for structural concrete, are not suitable for concrete for high-temperature service. Some natural aggregates may be used for heat-resistant concrete. Of these, trap rock is the most prominent. In addition to firebrick grog, manufactured aggregates for heat-resistant concrete include crushed paving-brick and hard-burned common brick. Air-cooled blast furnace slag can be used below 1000 F.

The making of heat-resistant concrete follows the principles outlined for high-temperature concrete in general. The specific considerations are that the concrete should have relatively high strength and that the service temperature will never be high enough to build up fired strength. Calcium-aluminate cement is used because it retains an effective part of its strength during and after long exposure to the anticipated temperatures, *i.e.,* up to 1500 F.

For the reasons explained in the last paragraph certain heat-resistant aggregates are used. Because no ceramic bond will be formed, the high percentage of fine aggregate used for refractory concrete is not necessary. The grading of the aggregate may be more nearly like that of ordinary concrete but the fines should be sufficient to give a plastic mix and dense

concrete. A comparatively rich mix insures high cold-strength.

In designing heat-resistant concrete installations, the lowered strength after heating must be taken into account. In floors the strength of the concrete at the surface will be materially reduced with consequent reduction in the wearing quality as compared with a similar floor which is not subject to heat. Nevertheless, when made with such tough aggregates as trap rock or emery and placed with a carefully developed technique, heat-resistant concrete floors have given satisfactory and economical service under rather severe conditions.

The strength factor must also be considered in designing reinforced heat-resistant concrete. Another important detail is the location of the reinforcement. The reinforcing bars or mesh should be so placed that their temperature will not exceed 600 F. At higher temperatures the tensile strength of carbon steel declines rapidly. It may also oxidize and become entirely ineffective as reinforcement. Special methods of reinforcing heat-resistant and refractory concrete are being developed. They should be investigated before any important work of this kind is undertaken.

Heat-resistant concrete is essentially structural concrete exposed to soaking heat. Typical installations are foundations under industrial furnaces and flues carrying hot gases. For example, such concrete has been used under the hearths of blast furnaces, for the concrete slabs supporting batteries of coke ovens, for waste-heat flues and top-paving of coke ovens. Heat-resistant concrete floors may be placed under and around furnaces where the soaking heat would disintegrate ordinary concrete.

Refractory Concrete: In describing the characteristics of refractory concrete it has been pointed out that the strength of the material in service is due to a combination of hydraulic bond and ceramic bond. Aggregates and mixes are selected accordingly. A high percentage of fine particles is included as the fines are mainly responsible for the ceramic bond. The preferred grading has 50% of the total aggregate passing a ⅛-in. screen with 15% or more passing a 100-mesh screen. Coarse particles may be ¾-in. or more, depending on the thickness of the section to be placed.

Mixes are generally stated in terms of volumes of total aggregate instead of stating the fine and coarse quantities separately. Thus, a 1:4 mix of Lumnite and grog means 1 cu. ft. (1 bag) of Lumnite and 4 cu. ft. of total aggregate. When it is necessary to regrade the aggregate by separating and recombining fine and coarse sizes, such a mixture should have 4 cu. ft. of the total recombined aggregate. This is not the same as 2 cu. ft. of each, because the smaller particles partially fill the voids in the coarse aggregate.

The refractory quality of the concrete depends on the nature of the aggregate and the proportions of the mix. In general, leaner mixes are used for higher temperatures. Increasing the percentage of Lumnite does not increase the refractoriness of the concrete. For temperatures up to 2000 F a 1:4 mix is generally used. Above 2000 F, mixes of 1:5, 1:6, or 1:7 are used according to temperature. For all temperatures up to 2500 F crushed firebrick or similar grog is the aggregate commonly employed. Above 2500 F the aggregate should have a softening point not lower than approximately 3000 F (Cone 30). Above 2750 F special super-refractory aggregates are used.

The foregoing paragraphs are not intended to give complete information on the preparation and use of refractory concrete but rather to serve as a description. A question is sometimes asked as to how refractory concrete can be used for service above the melting point of Lumnite, which is about 2450 F. The answer partly explains the reason for using leaner mixes at higher temperatures. The fused Lumnite combines with the aggregates to form new compounds which are stable at those temperatures. It is necessary, therefore, that the aggregate chosen be one which will so combine with the Lumnite. The selection of such aggregates and determination of mixes is the object of present research on high-temperature refractory concrete.

The ideal aggregate or combination of aggregates would be one with which a ceramic bond was developed at all temperatures above that at which hydraulic strength of the concrete is reduced through the dehydration of the cement. As the formation of ceramic bond above 1500 F is easily accomplished, the problem is to increase the strength of the concrete at temperatures below 1500 F. This would result in a more uniform strength gradient through the section of a wall heated on one side.

Insulating Concrete: The making of insulating concrete for high-temperature service follows the same principles as the making of heat-resistant concrete and refractory concrete. Both of these concretes may be made with light-weight aggregates which will greatly reduce their thermal conductivities. It happens that such aggregates are available and economical. In fact, the insulating concrete can generally be obtained at no greater cost than regular refractory concrete.

Calcined diatomaceous earth was probably the first aggregate used to any extent for high-temperature insulating concrete. It is good for temperatures up to 1800 F. Haydite, an aggregate manufactured from shale and originally intended for light-weight structural concrete, is popular for refractory insulating concrete in service up to 2000 F. Vermiculite, an exfoliated mica, is used either alone or in combination with Haydite or firebrick grog for service up to 2000 F. Above 2000 F insulating-firebrick grogs are used. The limit for refractory insulating concrete made with presently available commercial aggregates is about 2500 F. The proportions of Lumnite and total aggregate are in general about the same as those used for refractory concrete.

Common types of refractory insulating concrete, such as the Lumnite: Haydite and Lumnite: Insulating-grog mixtures have conductivity factors about one-third that of firebrick. The economic value of these concretes is apparent when it is realized that their cost generally is no greater—and frequently is less—than that of ordinary high-conductivity refractories. Thus, insulating or heat-saving value is free.

(To be concluded)

A Materials Article Not only materials engineers looking for data on high-temperature alloys but production men and metallurgists as well will be interested in this report of the successful and advantageous use of nickel and Inconel thermocouple protection tubes for lead pot, salt bath and controlled atmosphere service.

Nickel and Inconel Thermocouple Protection Tubes

by E. M. KLINE and A. M. HALL *International Nickel Co., Inc., Huntington, W. Va.*

THERMOCOUPLE PROTECTION TUBES are made of various materials—refractory or metallic, but usually the former—depending on the conditions of temperature, mechanical service and environment of the thermocouple service. We have had such satisfactory and economical performance from protection tubes made of pure nickel and of Inconel (80 Ni, 14 Cr, 6% Fe) as to feel justified in publishing our experience for the benefit of others who may also find metal protection tubes of this type an improvement in certain cases.

Metal thermocouple protection tubes are used by us primarily to protect the enclosed thermocouple against mechanical shock and secondarily to protect it from chemical attack by the surrounding medium, gaseous or liquid. Nickel and Inconel protection tubes have been found effective for service in molten lead or salt baths and in reducing atmospheres—all of which have come into increased use for heat treating in the last few years. In oxidizing atmospheres they are not required for corrosion reasons but are helpful if mechanical shock is involved.

The metal protection tube is made of cold drawn seamless tubing closed at the hot end by a welded-on disc of the same metal. In general and where possible the installation in the furnace is vertical rather than horizontal. In the latter position, especially at high temperatures, difficulties may be encountered through sagging of the protection tube (see Fig. 1).

The accompanying Table presents data on service conditions and service life of nickel and Inconel protection tubes in lead bath, salt bath and reducing atmosphere applications. Detailed information on these uses is given in the following paragraphs.

Molten Lead and Salt Baths

Inconel protection tubes are used in applications involving immersion in molten lead (see the Table). For best service the protection tube is soft annealed prior to use (a thorough anneal is absolutely necessary to remove the danger of splitting from stress corrosion, as shown in Fig. 2).

A typical example is a lead coating tank operated at 700 to 800 F. In use the Inconel protection tube is immersed in liquid lead covered with the following flux:

	Per Cent
Ferric chloride ($FeCl_3$)	20 - 30
Ammonium chloride (NH_4Cl)	5 - 10
Zinc chloride ($ZnCl_2$)	75 - 60

This chloride mixture, though very active chemically does not "cut into" the Inconel protection tube.

Another case is a high temperature lead pot operated at 1400 to 1800 F, used for the heat treatment of steel. The protection tube is immersed in the lead through a cover of crushed charcoal. Fig. 3 shows the tube, which after three years in service is perfectly sound and is still in use.

Nickel protection tubes may be used for immersion in fused chlorides in the absence of sulphur, for example in barium chloride at 1850 to 2000 F, or in sodium and potassium chlorides operated up to 1800 F (*e.g.*, E. F. Houghton Co.'s Mixture No. 168).

Inconel is recommended in cases where there is danger that the salt bath may be contaminated by sulphur.

Inconel is also satisfactory for use in cyanide baths used for the liquid case-hardening of steel. One Inconel protection tube used in E. F. Houghton Co.'s "Perliton" operated at 1450 to 1600 F is still in ser-

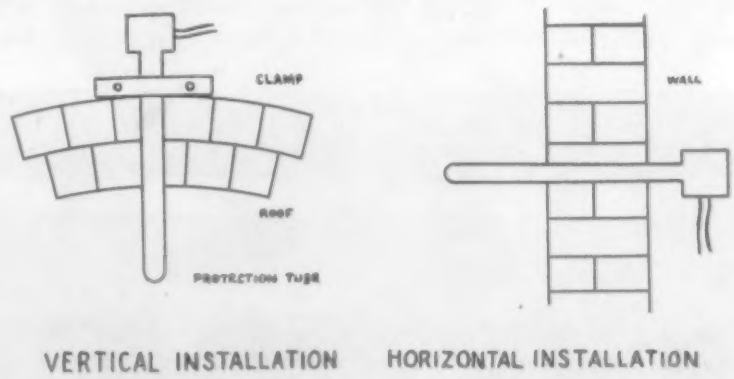


Fig. 1. Vertical and horizontal installation of the protection tube. The former is preferable.

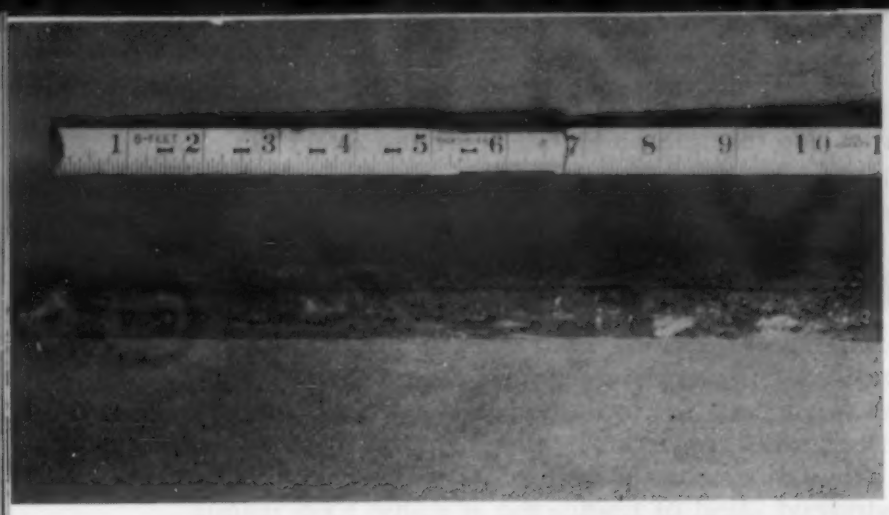


Fig. 2. An Inconel thermocouple protection tube immersed in lead bath operated at 700 to 800 F. The tube became embrittled by the lead and split after about 1 mo. in service. It had not been thoroughly annealed.

Fig. 3. An Inconel thermocouple protection tube immersed in a lead bath to a depth of about 6 in., operated at 1400 to 1800 F. It is perfectly sound after 3 yr. service.

vice after more than three years intermittent use of this carburizing bath.

Reducing Gas Atmospheres

The reducing atmospheres in which we have used metal protection tubes are generated in open furnaces by the incomplete combustion of mixtures of low sulphur natural gas and air. For such atmospheres either nickel or Inconel is used, but as a rule nickel is preferred because the gas molecules have somewhat more difficulty permeating it to attack the enclosed thermocouple. Figs. 4 and 5 show microscopically what happens to nickel in this type of service.

Fig. 4 represents a location at the outside surface on a transverse section of a nickel tube which had been exposed to a reducing atmosphere (about 5% CO) for one year. The effect of the exposure was to gradually develop voids in the metal. Along the surface the condition is general, but in depth the voids occur only at the grain boundaries.

Fig. 5 reveals that at the inside surface the condition is considerably different. The metal was exposed to air and an adherent, continuous oxide coating resulted. A few intergranular islands of oxide were also found.

Permeability is very important in considering reducing gas atmospheres because the carbon monoxide and hydrogen which are usually their chief components are extremely harmful to thermocouples. When precious metal thermocouples are used an inner protection tube of a refractory material (*e.g.* mullite) is also used to increase the protection from gaseous attack, as shown in Fig. 6. This extra precaution is not usually taken when base metal thermocouples are being employed.

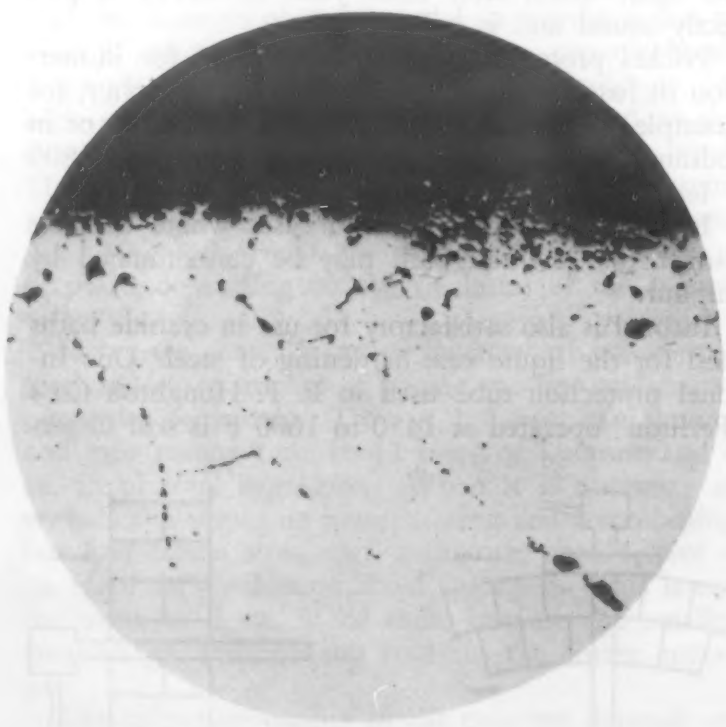


Fig. 4. Photomicrograph (50X) of nickel thermocouple protection tube used in reducing gas atmosphere—transverse section of outside surface. The dark areas in the metal are voids.

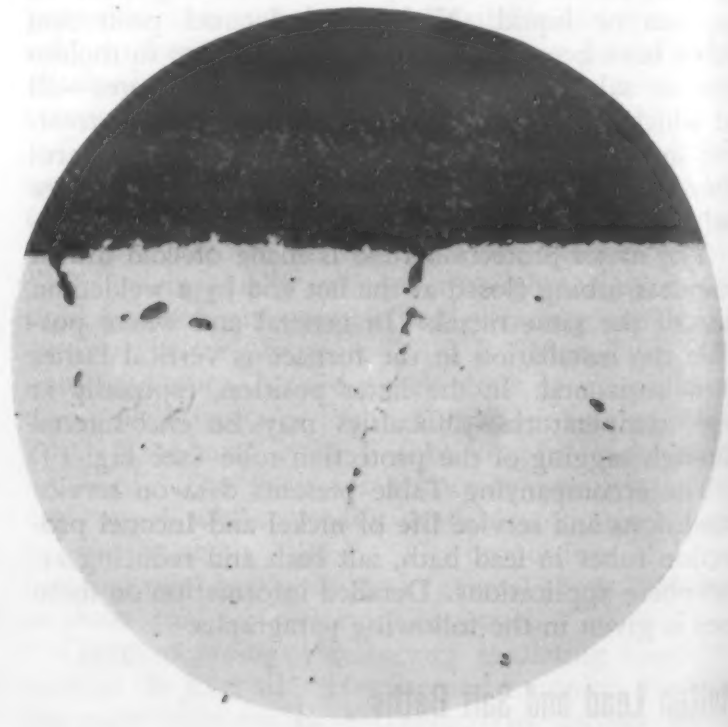


Fig. 5. Photomicrograph (50X) of nickel thermocouple protection tube used in reducing gas atmosphere—transverse section at inside surface. The metal has been heavily coated with oxide.

Nickel protection tubes are also used in the artificial bright annealing atmosphere which is a mixture of 10% by volume hydrogen and 90% by volume nitrogen. At higher hydrogen concentrations the metal protection tubes are useless because of the great permeating power of hydrogen, but at this concentration and at moderate temperatures long life is obtained, as the Table shows.

To Resist Mechanical Breakage

In general, thermocouples are not sheathed when used in oxidizing gas atmospheres because the oxidizing gases are not harmful to them. However, applications are encountered where protection against mechanical damage is necessary. Here, nickel protection tubes are used because the adherent, continuous and relatively impenetrable oxide coating which forms on the metal provides it with long life. At moderate temperatures the life of the metal is almost indefinite, as the data in the Table show. A typical example is the use of nickel protection tubes for roof thermocouples in a box annealing furnace operating at 1000 to 1450 F. The atmosphere contains about 2% oxygen.

Inconel is used as a substitute for expensive high temperature refractory protection tubes in dry heat applications up to 2300 F where mechanical shock is very likely. The refractory materials are brittle, especially when hot, whereas Inconel retains considerable stiffness and is ductile. It is, incidentally, stiffer than nickel at all temperatures.

In one application, the front thermocouple projecting down through the roof of a quench-annealing furnace operating up to 2300 F is protected by an Inconel tube. The refractory tube formerly used was repeatedly broken by being struck during charging and discharging the furnace.

For the great majority of thermocouple applications, of course, metal sheathing of this type is unnecessary; but for service like that described in this article it will be found highly useful and economical.

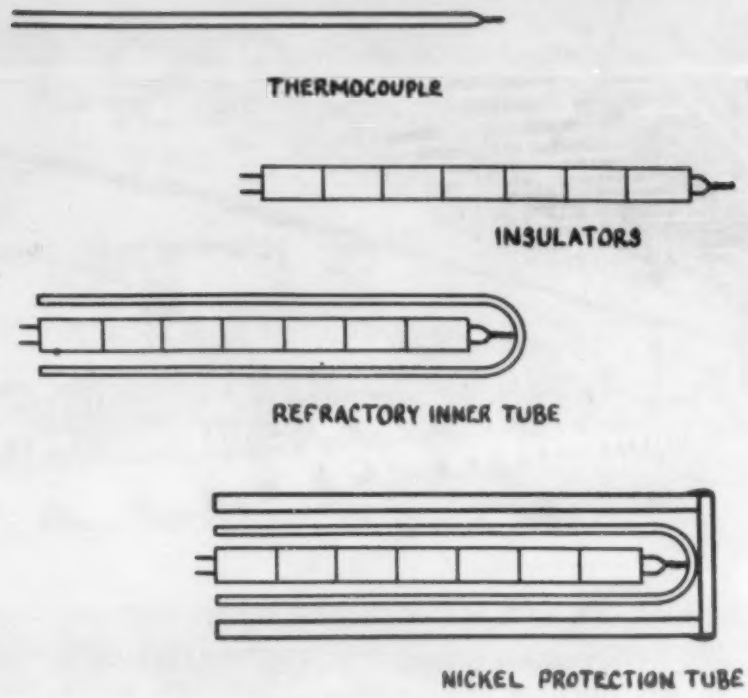


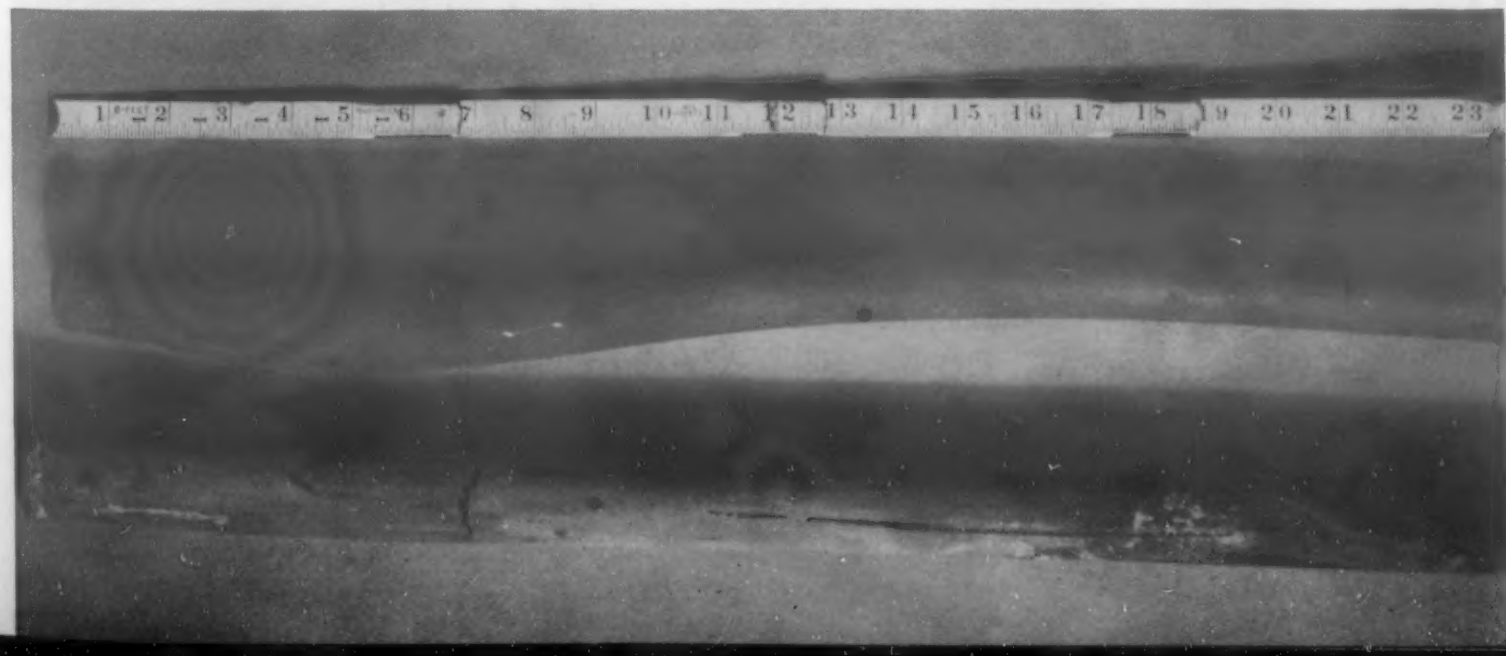
Fig. 6. Methods of protection of precious metal thermocouples.

Table of Thermocouple Protection Tube Service

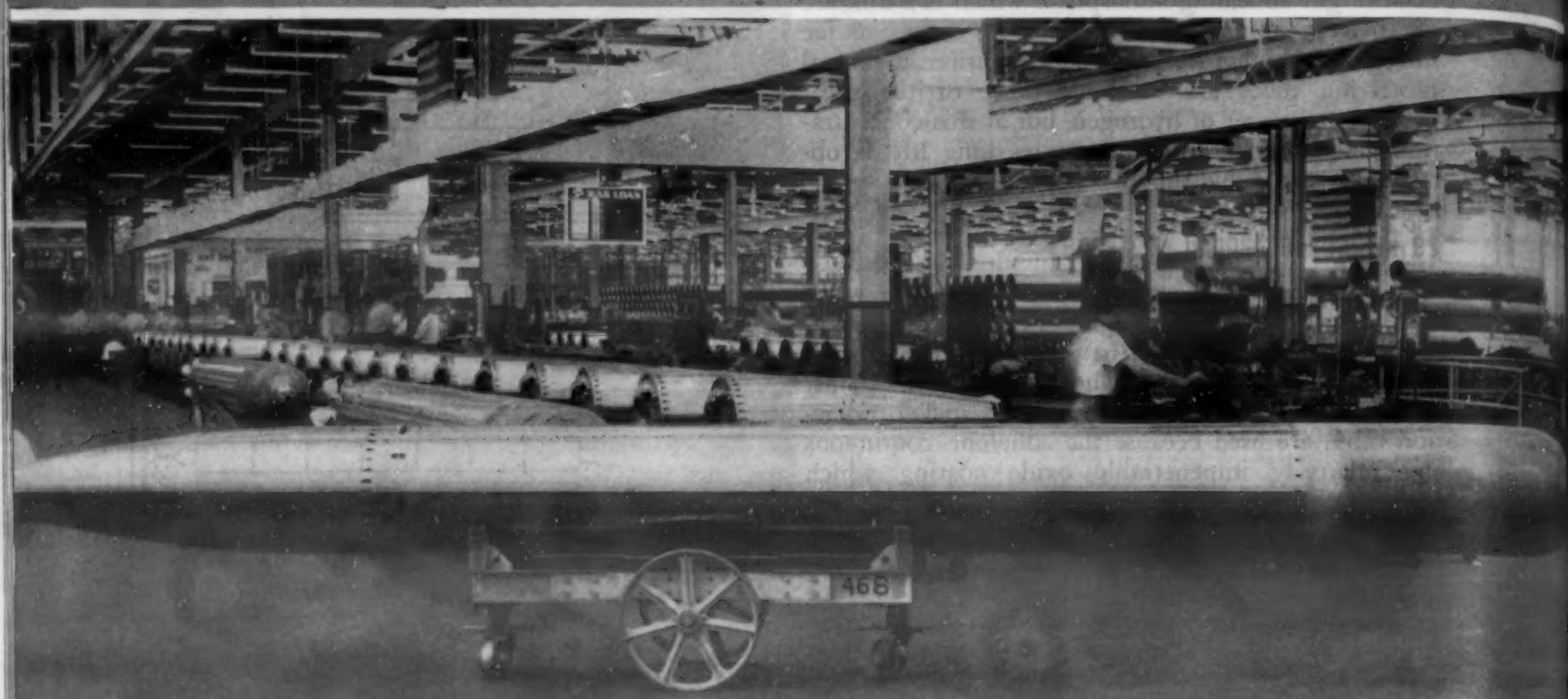
Metal	*Temperature Range*	*Composition of Gas, %*							*Other Media*	*Size*	*Life*
		O_2	CO	CO_2	N_2	H_2	H_2O	S			
Inconel	700 - 1800 F	—	—	—	—	—	—	—	lead	1" IPS	3 - 5 yr.
Inconel	1450 - 1600 F	—	—	—	—	—	—	—	Perliton [1]	1" IPS	3 - 5 yr. - Intermittent operation
Inconel	1800 - 2300 F	—	5.0	8.0	64.0	5.0	18.0	0.0008 [2]		1" IPS	1 - 2 yr.
Inconel	1800 - 2200 F	—	2.0	11.0	64.0	2.0	21.0	0.0008		1" IPS	1 - 2 yr.
Nickel	1000 - 1450 F	2.0	—	11.0	66.0	—	21.0	0.0008		1" IPS	5 - 10 yr.
Nickel	1500 - 1950 F	—	5.0	8.0	64.0	5.0	18.0	0.0008		1" IPS	1 - 2 yr.
Nickel	1250 - 1450 F	—	—	—	90.0	10.0	None	None		1" IPS	5 - 10 yr.

[1] Perliton is a proprietary carburizing mixture containing a cyanide compound. Manufactured by E. F. Houghton Co.
[2] 0.50 grains per 100 cu. ft. of gas.

Fig. 7. Nickel thermocouple protection tubes after 1 yr. service in a continuous sheet annealing furnace operated at 1650 F. to 1950 F. with a burned natural gas atmosphere containing about 5% CO. One tube had failed by cracking, while the other had been struck and bent but was otherwise perfectly sound.



A Methods Article "Precision fabricating and machining at their utmost" is the best characterizing phrase for American Can Co.'s Amertorp plant's torpedo-manufacturing operations, presented here in pictures that tell the story better than a thousand words.



A single punch from one of these weapons can shatter a $50,000,000 battleship. The torpedo contains 3,000 delicately fashioned parts and is comprised of five integrated sections of highly polished stainless steel—the warhead, air flask, mid-ship section, after-body and tail cone section. The one depicted here is a Mark 15.

The Manufacture of Navy Torpedoes

—A Plant Visit in Pictures

ONE OF THE NAVY'S deadliest weapons is an amazingly accurate robot engine of destruction that steers its own course, generates its own power, carries its own infallible mechanical crew and speeds unerringly to the target. When Farragut, at Mobile Bay, exclaimed "Damn the torpedoes," he referred merely to irritating mosquitoes alongside this modern jewel-finished ton or more of death.

First private builder of a torpedo in this war, the Amertorp Corp., wholly-owned subsidiary of the American Can Co., had doubled contract production within 18 months after the first weapon was completed at Forest Park, Ill. In six months it had tripled anticipated results. American Can operates a second torpedo plant at St. Louis, the two costing over $30,000,000.

A large part of the tools, jigs and fixtures were built in American Can's own shops. The company supplied other plants with layouts, tool designs and parts.

So delicately adjusted is the gyroscope that a speck of dust or extra drop of oil applied to a bearing with a hypodermic needle can destroy its balance or reduce its potential speed. —H.A.K.

Here is an assembly line at American Can Co.'s Amertorp plant in St. Louis.

These vulnerable welders are doing their work rather disadvantageously within the armor case heads. (This picture is not to be confused with the "after-body" photo, a few illustrations later. American Can, indeed!)

A giant lathe is machining the center section, or air flask.

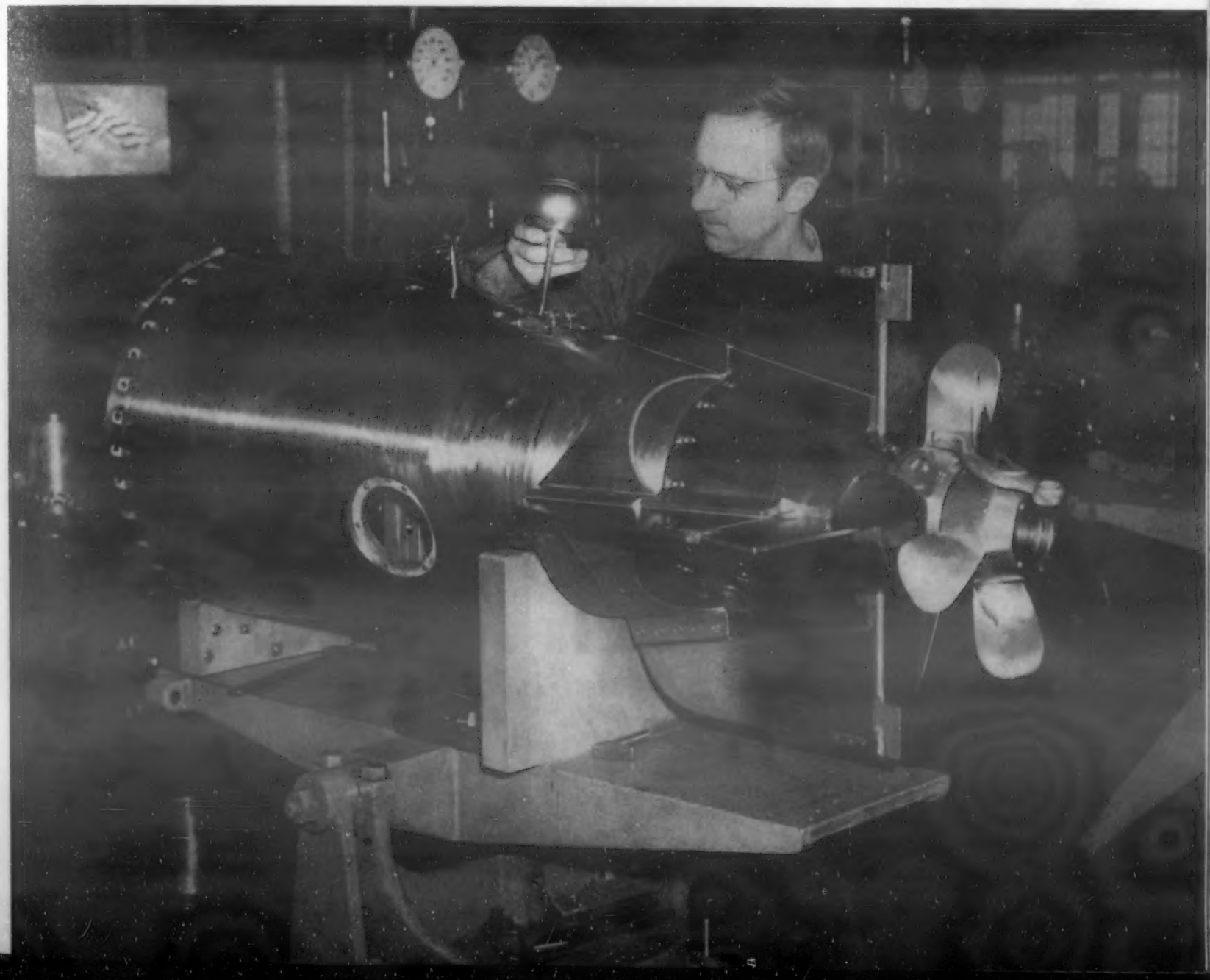
Even an infinitesimal scratch on a part of the gyroscope, "the brain," is cause for rejection.

Trucks are conveying torpedo parts to the assembly departments. Attention please, keep eyes to the extreme left and observe the torpedo parts.

It takes a former watchmaker in one of the country's most exclusive jewelry shops to provide the necessary skill for assembling "gyros."

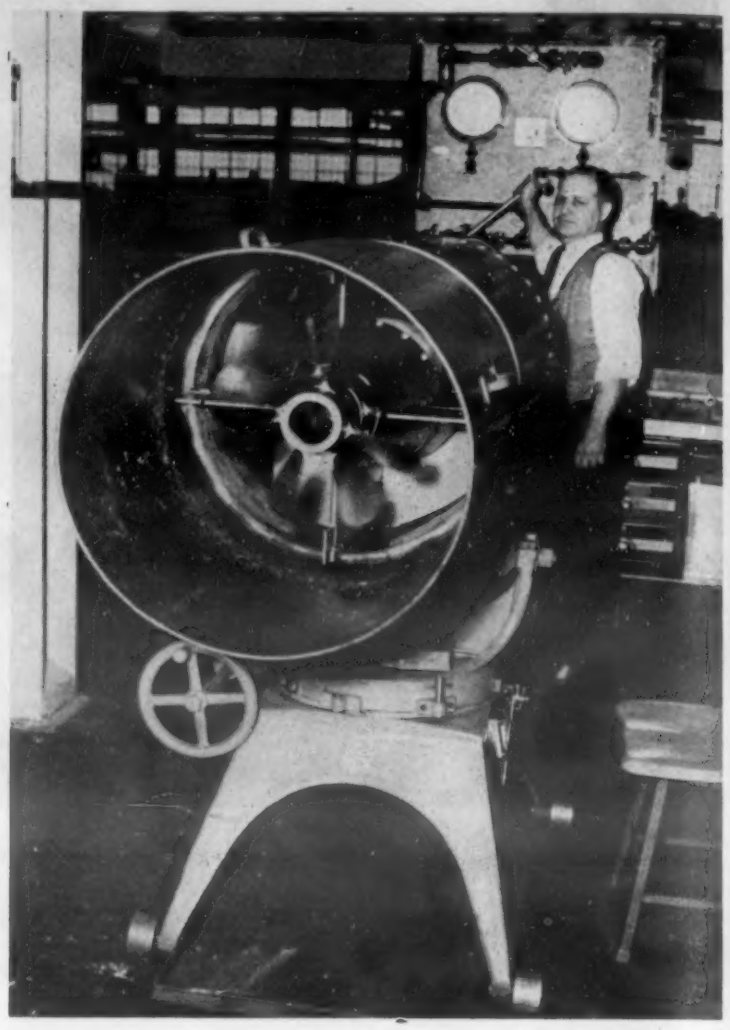
An internal grinding machine, resembling a big gun, does an important job.

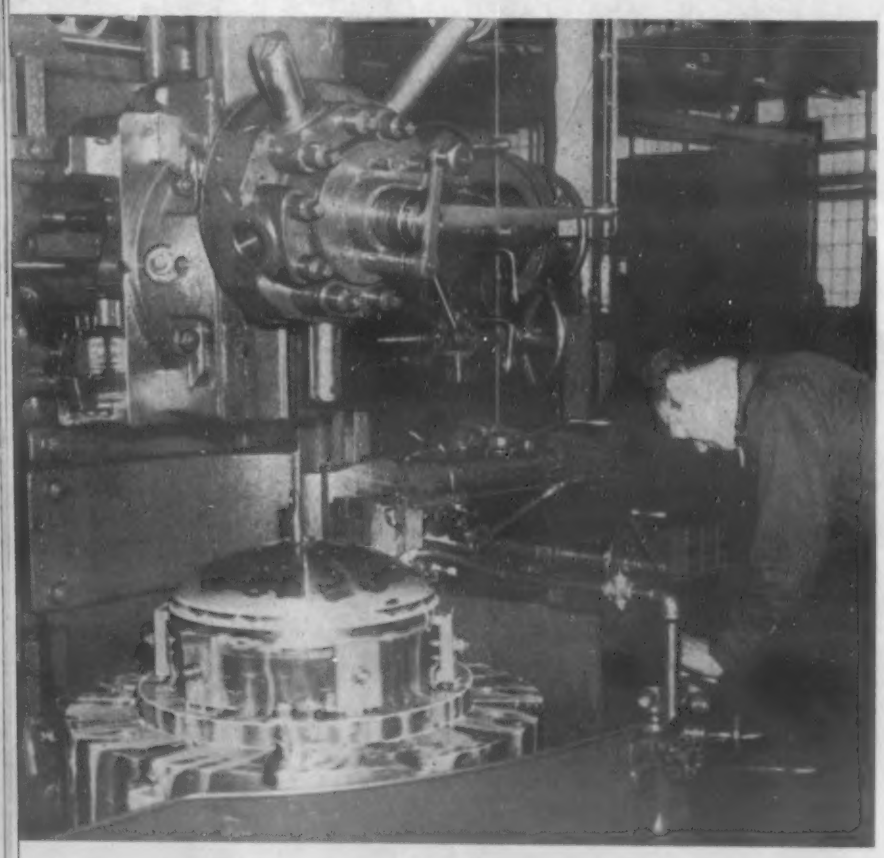
In this after-body are contained a steam turbine, gyroscope and steering mechanism. The workman is putting on finishing touches.



Cutting and finishing a turbine wheel formerly used up 11 hr. of hand and machine work. It is now finished in 3½ hr., using specially developed methods.

A double set of propellers start to spin as a workman gives the engines a final test on an assembly line.





This large automatic machine turns out bulkheads for a compartment that holds the water needed to make steam for a torpedo's turbines.

A super finishing machine completes bearings for gyroscopes four at a time, producing surfaces of ultra-high finish.

Electropolishing of Microspecimens

by ULRIC J. HOCHSCHILD *Metallographer, United States Metals Refining Co., Carteret, N. J.*

A Methods Article In this article—a sequel to another practical metallographic-methods report by the same author in our December 1944 issue—Mr. Hochschild discusses the electropolishing technique and describes an ingenious method for mounting small specimens that combines the processes of powder metallurgy and plastics molding in its application.

IT WAS MENTIONED in the author's article in the December issue that one of the purposes of chemical etching is to remove the layer of worked metal, formed by the grinding and polishing operation, from the specimen under investigation. This can sometimes be accomplished only by a deep etch. The resulting etching pits and heavy appearance of the grain-boundaries are liable to cover up completely the picture of any fine holes or inclusions peculiar to the specimen under examination.

In recent years the development of the method of electropolishing has furnished us with a means of removing from the specimen surface the worked metal layer due to grinding and buffing without etching the specimen. After filing and grinding in the usual manner the specimen is, with this method of polishing, placed as an anode into a suitable electrolytic cell. Electric current passed through this cell under certain conditions electrolytically dissolves the specimen surface in contact with the electrolyte in such a manner that its surface gradually assumes a smooth mirror-like appearance[1, 2].

Electrolytic Polishing Described

The generally accepted explanation of the electrolytic polishing process is as follows: The soluble anodic corrosion products form a concentrated liquid film of about ½ mm. thickness over the specimen surface. This film diffuses slowly into the electrolyte and is maintained by the continuous electrolytic dissolution of the anodic specimen surface. This film offers electrical resistance to the current. The value of this resistance, depending on the film thickness, slows down the electrolytic action most where its thickness is greatest. This will be at the valleys formed by scratches on the specimen (see Fig. 1). The high ridges of the specimen surface, on the other hand, reach some distance into this film and so become more exposed to the action of the electric current. This differential action on the specimen surface results in a gradual smoothing out and polishing.

Current density must be accurately controlled for electropolishing as explained in the following: If the current is plotted against the voltage across the cell the resulting curve is of a shape as indicated by Fig. 2. Polishing takes place when current conditions correspond with the horizontal straight portion of the curve. The course of the curve is readily explained by the formation of the above described film of concentrated anodic corrosion products. At first the current increases proportionally with increasing voltage since diffusion of the film takes place at a higher rate than its formation. If the cell voltage is raised further, a point is soon reached where the increased formation rate of the film balances its diffusion rate. From here on increased voltage merely increases the thickness of the said film which, in its own turn, tends to limit the flow of current by its higher electrical resistance.

If, however, the voltage is raised above a critical value it will puncture the film and attack the anode vigorously under evolution of oxygen. At this point

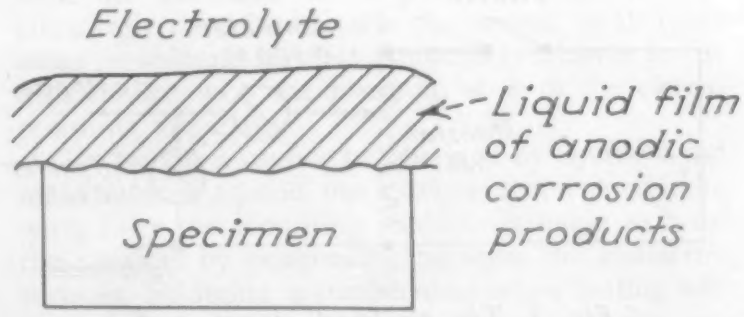


Fig. 1. Liquid film of anodic corrosion products.

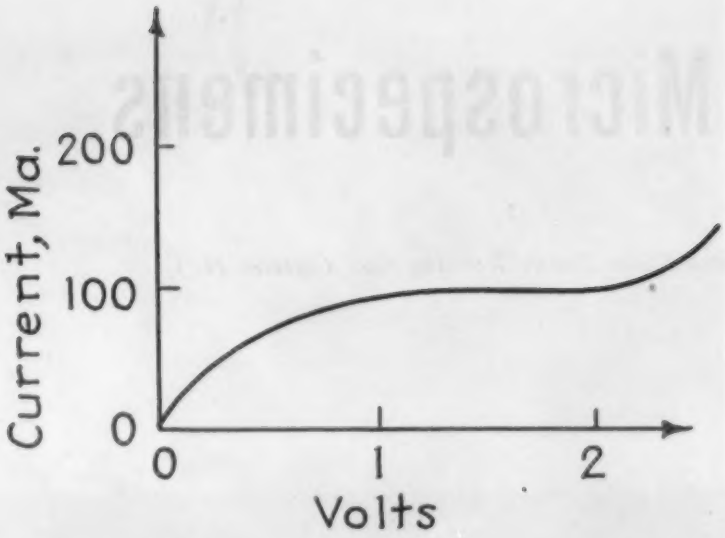


Fig. 2. Current plotted against the voltage.

the curve begins to ascend again, since no matter how fast the film is formed it is continuously broken down by the increased voltage resulting again in a proportionally increasing flow of current. In this range polishing is interfered with, since the oxygen gas bubbles adhering to the surface of the specimen protect the underlying metal from further attack resulting in raised spots.

When, on the other hand, the current for polishing is too low (first ascending portion of the curve) a differential attack as described cannot be obtained, since the anodic corrosion products diffuse into the electrolyte as soon as formed and a film is therefore not built up. The action of the electrolyte then becomes more of a chemical nature, etching the specimen instead of polishing it.

Electropolishing Method in Practice

Various constructions of apparatus and electrolytes have been devised for electropolishing. Some methods employ vertically arranged electrodes[3]. The writer has found, however, that with copper and copper alloy specimens more even and smoother surfaces are obtained by using horizontally placed specimen and cathode. The illustration (Fig. 4), shows the electropolishing apparatus used in the laboratory of the United States Metals Refining Co., Carteret, N. J. The anode consists of a horizontal platinum support with a platinum spring. Both, horizontal anode and cathode, are mounted on a wall panel which also accommodates the current controlling rheostat, switch, volt- and ammeters.

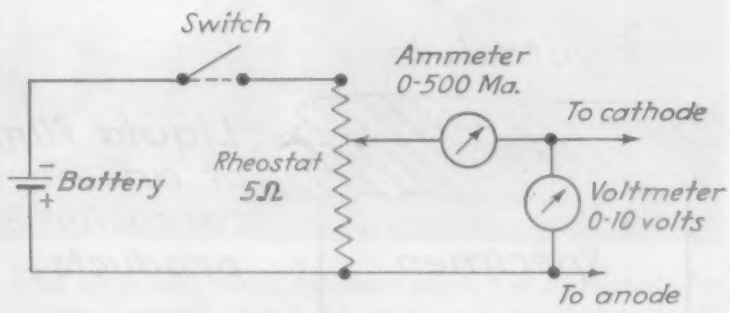


Fig. 3. The electrical circuit used.

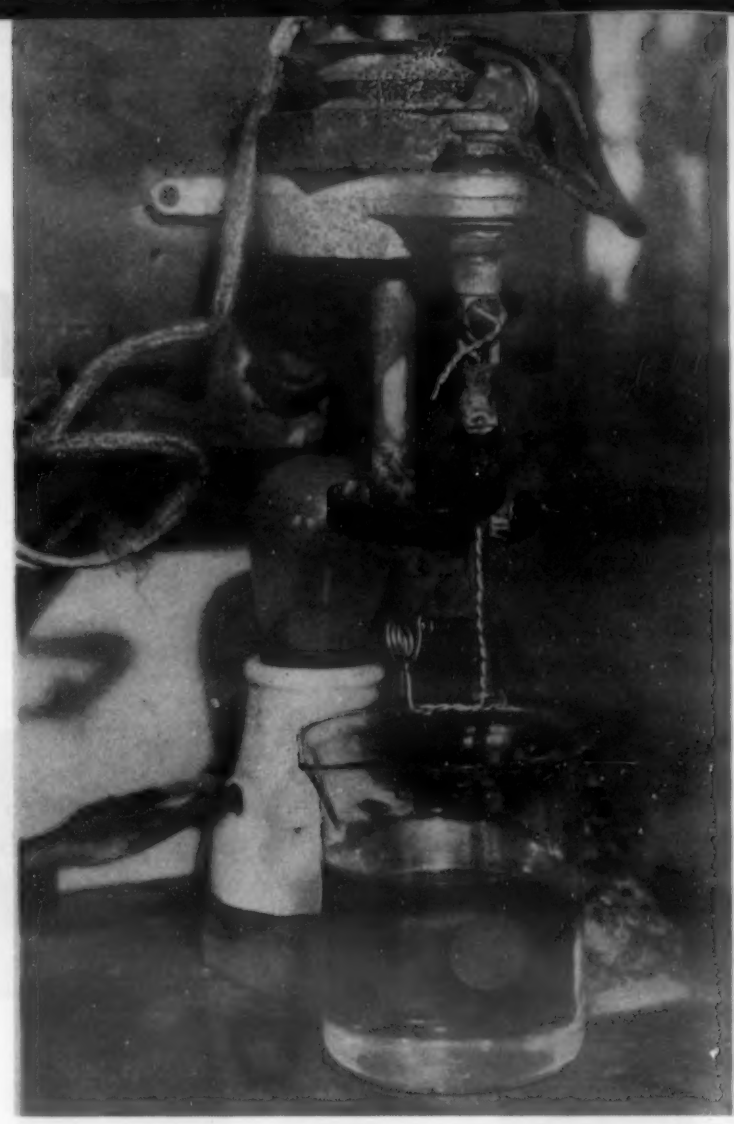


Fig. 4. The electropolishing apparatus.

For polishing, the specimen is clamped onto the platinum support so that the surface to be polished is horizontal and facing up. Electrical contact is made by a platinum wire touching a corner of the surface of the mounted specimen under light spring tension. This platinum spring can be left off an unmounted specimen, since in that case electrical contact is already ensured through the bottom of the specimen resting on the platinum support. A beaker of 250 cc. capacity contains the electrolyte. This is raised onto a support, so that both, anode and cathode, become submerged in the electrolyte.

For polishing copper and copper alloys this consists of a mixture of water and orthophosphoric acid with a resulting density of about 1.4 g per cm^3, and is used at room temperature after boiling off any dissolved gases. The height of the horizontal cathode is adjusted by means of a clamp, at a distance of ¾ to 1 in. above the specimen. The cathode consists of a perforated copper disc, the lower side of which is coated with an insulating paint to restrict the evolution of hydrogen to its top surface. This helps to prevent gas bubbles from reaching the specimen, where they might adhere with the detrimental effects already mentioned.

In order to prevent further the formation of gas bubbles on the specimen it is necessary to boil the electrolyte occasionally. The arrangement of the cathode also confines the electrolytic deposition of copper powder to its top surface, thus preventing the powder from falling onto the specimen, where it would cause the same kind of damage as caused by gas bubbles. The perforations in the cathode disc ensure even current distribution toward the specimen.

The electrolyte can be used repeatedly. With continued use, however, copper builds up in solution and interferes with visual observation of the specimen during polishing. The dissolved copper can then be removed by electrolysis; the density of the electrolyte can be readjusted by adding water or orthophosphoric acid as required, and after removing dissolved gases by boiling, it can be used again.

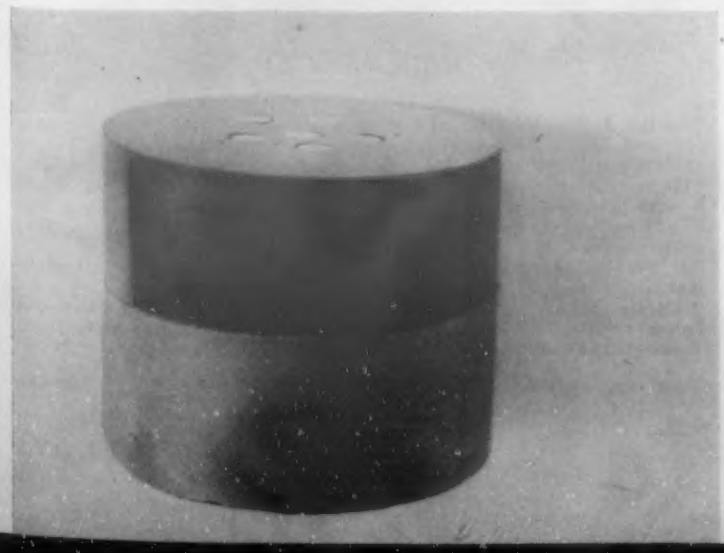
Electric current is furnished by a 6-volt storage battery and is adjusted by means of a variable rheostat of about 5 ohm resistance. The electrical circuit is shown by Fig. 3.

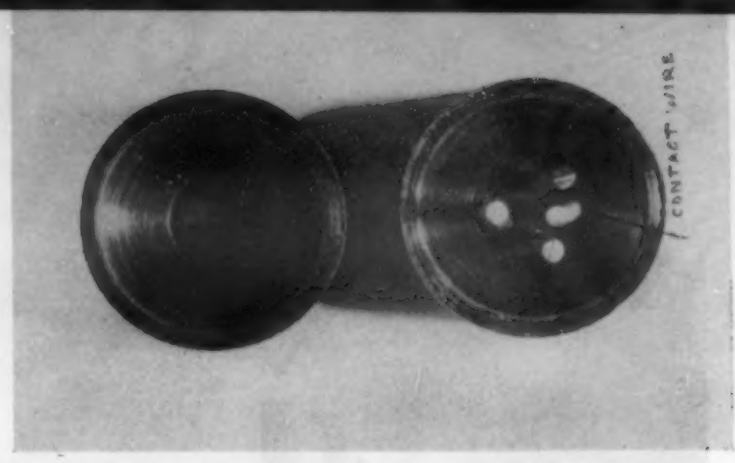
The current density employed for polishing is of the order of 5 to 10 amp. per sq. dm. specimen surface area. The cell voltage is about 1 to 1.6 volts. Both current and voltage depend on the dimensions of the sample to be polished. In order to adjust the current conditions to correspond to the horizontal portion of the current-voltage curve (described above), the rheostat is slowly advanced from its zero volt position until the current does not only fail to increase any further with increasing voltage but actually drops to a fraction of its original value. While advancing the rheostat, the current will first assume a comparatively high value, say 500 MA, after a few seconds it will gradually decrease to, say 250 MA.

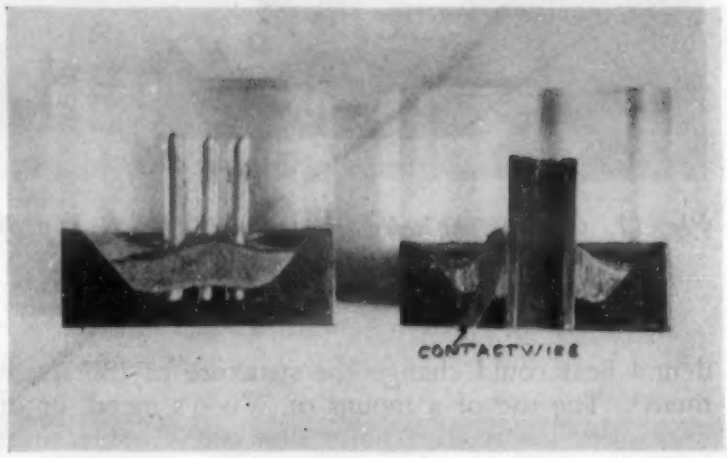
While still advancing the rheostat slowly, a position is soon reached where the current drops suddenly to a still lower value, say 100 MA, and immediately begins to oscillate at a rapid rate between this value and the value existing just before the sudden drop occurred (in our example, 250 MA). This oscillation will stop, the current stabilizing itself at the lower value, when the voltage is raised slightly more by the adjustment of the rheostat. Best conditions for polishing are obtained at about 0.1 volt above the voltage at which the current oscillations occurred.

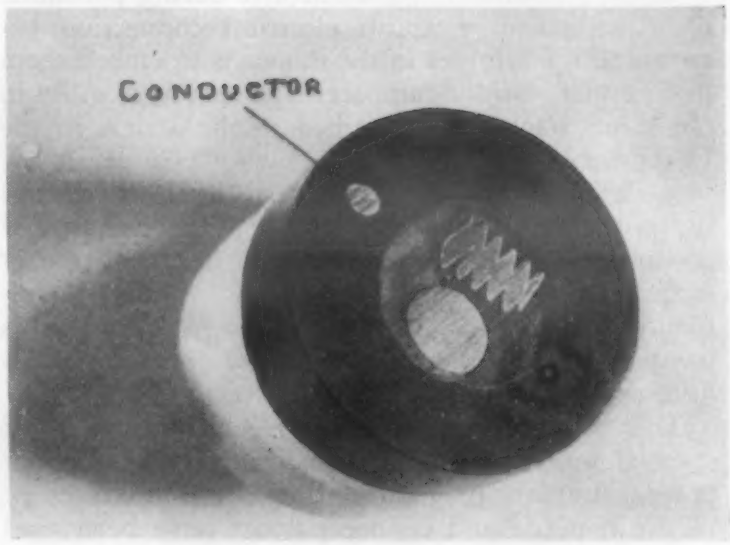
Agitation of the electrolyte would destroy the film on which polishing depends and must, therefore, be strictly avoided. Another precaution to be taken consists of avoiding prolonged contact of the specimen with the electrolyte except when properly controlled electric current is flowing, since otherwise etching will occur. For this reason the specimen must immediately following removal from the electrolyte (before switching off current) be washed by gently swabbing with cotton under running warm water; after which it is dried by blowing with air. The time required for electropolishing depends on the thickness of disturbed metal on the specimen surface and on the depth of its scratches, and ranges from 10 to 40 min.

Fig. 5. Copper powder used in building up the second part of the mount.









Figs. 6 to 10. New technique for the preparation of mounts.

Difficulties With Small Mounted Specimens

When polishing larger mounted specimens electrical contact is made as described in the foregoing by a platinum wire which under light spring tension touches a corner of the specimen surface. With smaller specimens, such as pieces of wire, this method has its limitations, since the cross-section of such a sample is much too small and only one specimen at a time could be contacted in this way. This problem has been solved by mounting an additional wire along with the specimens to be polished. This must be electrically connected, inside the mount, to all specimens in order to serve as a mutual conductor to furnish contact with the platinum wire in the electropolishing apparatus.

Good contact cannot be obtained by simply winding fine wire around the specimens and conducting wire, since the mounting medium is liable to break the contacts by penetrating between the contacting surfaces. Soldering is cumbersome when dealing with a number of specimens in one mount, and the inci-

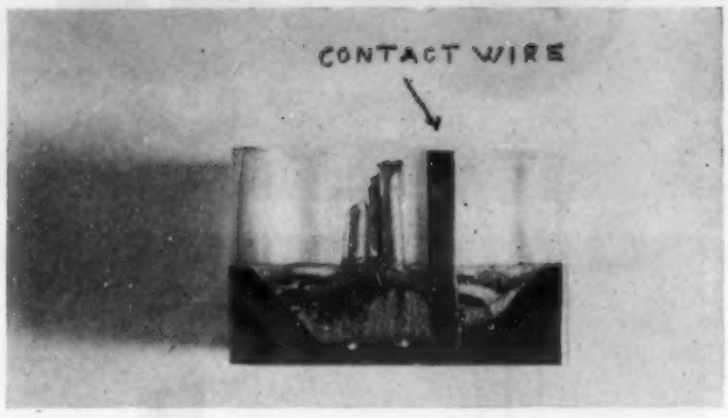


Fig. 11. Conducting wire led out through the top of the mount.

dental heat could change the structure of the specimens[4]. The use of a mount of Wood's metal, or of some other low melting-point alloy is unsuitable, since it would contaminate the electrolyte during polishing.

A method to establish electrical connection between all the samples in the mount is to embed them in a copper powder compact. The mount is made in the same manner as described in the article in the December issue, with the following change in the procedure. Copper powder instead of plastic mounting powder is used in building up the second part of the mount, as is illustrated by Fig. 5. Electrical contact is thus made between all specimens. Similar to unmounted specimens, this mount is placed with its compressed copper powder part down onto the platinum anode in the electropolishing cell.

This method has been employed by the writer for several months. Other methods using straight copper powder mounts or mounts employing mixtures of plastic material and copper powder have been used by the writer, and also by other workers for a year[5].

All these methods wherein the copper powder compact is exposed to the electrolyte have, however, the following disadvantages:

(1) Compared with the small surface area of the specimens the surface of the copper powder compact is very large, making it difficult to control current density on the surfaces to be polished.

(2) Within a short time the electrolyte destroys the copper powder part of the mount due to electrolytic dissolution aided by the porosity of the compact.

(3) The destruction continues on storing the mount, since it is impossible to wash all electrolyte out of its pores, so that after a few months' or even weeks' time electrical contact is destroyed and it becomes impossible to repolish the specimens electrolytically.

(4) The greatly increased flow of current passing through the electrolytic cell during electropolishing leads to a higher evolution rate of hydrogen gas at the cathode, causing some agitation of the electrolyte. To some extent hydrogen gas dissolved in the electrolyte and might lead to the appearance of gas bubbles at the specimen. To avoid this, more frequent boiling of the electrolyte becomes necessary.

New Method for Mounting Small Specimens

The writer has developed a new method which overcomes all the listed disadvantages. Figs. 6 to 10 illustrate this new technique for the preparation of mounts for small specimens intended to be electropolished. By means of a suitable die a small cup of a thermosetting plastic material is made in a manner similar to that for the preparation of the disc holder described in the December article (Fig. 6). This cup serves both as a specimen holder and a container for a copper powder compact. While Figs. 8 and 9 each show a longitudinal section through finished mounts, Fig. 10 illustrates the full view of another completed mount.

All mounts are made in the following manner: The cup-shaped holder is placed on the bottom plate of the mold assembly. The specimens, together with a wire which later is to furnish electrical contact with the platinum wire in the electropolishing apparatus, are then inserted as shown by Fig. 7. A very small layer of either thermoplastic or thermosetting mounting powder is then placed into the bottom of the cup to seal the fine spaces between the specimens and the holder. Then a layer of copper powder is filled into the cup almost to its capacity.

After placing the mold cylinder over the whole assembly, either opaque and thermosetting, or transparent and thermoplastic mounting powder is added to the desired height. In the beginning only light pressure is applied, say 500 p.s.i., in order to leave the copper powder in a flexible condition. Heavier pressure, say 4,000 p.s.i., is applied only after the melting-point of the plastic is reached. In this manner pressure is transmitted throughout the mount, compacting both layers of plastic and the copper powder simultaneously.

The conducting wire, furnishing contact from the outside of the mount into the hermetically sealed copper powder compact, can be positioned in any preferred manner. For instance, Fig. 11, shows it being led out through the top of the mount (bottom of the mount during electropolishing); while Figs. 8 and 9 show it being led out on the same side as the specimens.

With this method of mounting the copper powder compact being enclosed cannot interfere with electric current control during polishing. It is completely protected from any sort of corrosion, thus assuring a permanent electric contact inside the mount. Visual inspection of the interior of the mount is still possible by using transparent mounting powder in the uppermost layer of the mount (bottom during electropolishing).

The writer wishes to express his indebtedness to the management of the United States Metals Refining Co. for permission to publish these methods, and to Messrs. H. M. Schleicher and Max Heberlein for their greatly appreciated help and advice in their development.

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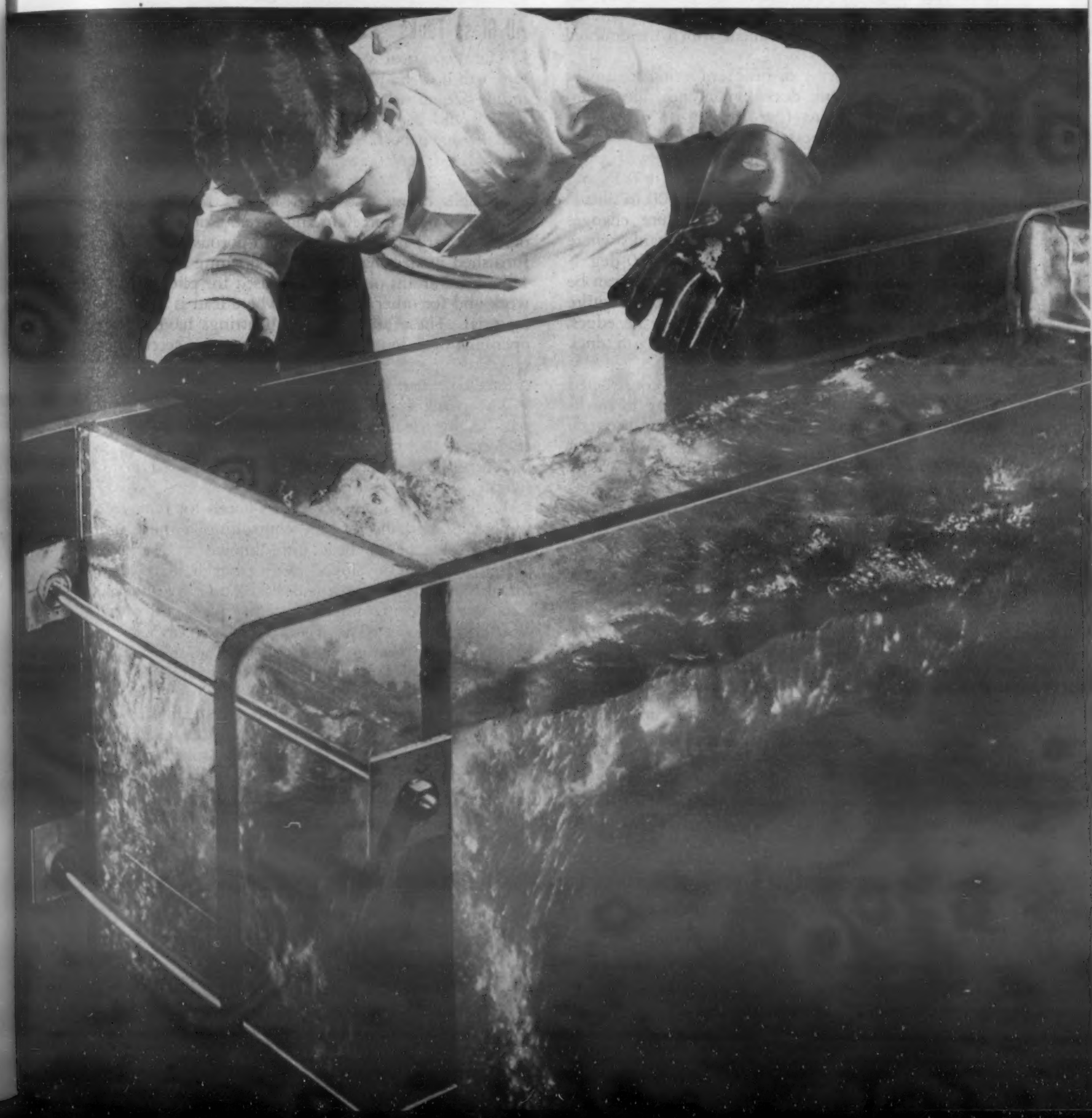
A Materials Article This article—additional proof in black-and-white that a good knowledge of materials means better process engineering—reports on the service properties and some applications of glass-lined and all-glass tanks, embodying a new high-strength and thermal-shock-resistant glass, for handling corrosive solutions in the metal-working industries. The glass will thus be a competitor of corrosion-resistant alloys for those jobs and for chemical-process-industries equipment as well.

Glass Tanks for Pickling and Plating

by GEORGE L. WEST *Manager, Structural Glass Department, Pittsburgh Plate Glass Co., Pittsburgh*

A boiling test in a heavy transparent glass tank.



MANY ENGINEERS are coming to believe they have found in glass tanks the answer to the tricky problem of handling corrosive solutions used in pickling and plating, and to other problems in factories and laboratories handling acids.

Industry generally had long accepted the fact that all the tank materials ordinarily used eventually broke down under the action of highly corrosive solutions. Early in the war emergency many plants were thus caught "short" because replacements just were not available. During the past two years, the Pittsburgh Plate Glass Co. has made several hundred installations and the response has been most gratifying. Industrial firms discovered the glass tanks did not break down; therefore, shutdowns for repairs were eliminated.

One of the best testimonials came from an assistant superintendent of a Westinghouse plant which installed a battery of 40 tanks. "They are the answer to a long sought for solution," he said. "They are easy to handle, they clean easily, and they are standing up under some heavy punishment which we doubted they could take."

The Herculite process, or heat tempering treatment of glass made the tank development possible by increasing its strength to four times that of regular glass of the same thickness. It can be applied to either transparent or opaque glass, which then will withstand instantaneous temperature shock of 400 F., and continuous working temperatures from 500 to 600 F. It therefore is impervious to temperature changes likely to take place in pickling or plating tanks where the maximum temperatures rarely exceed 250 deg.

What this means in terms of actual impact can be judged by the fact that a piece of ¾-in. Herculite plate glass, 12 in. sq., supported only on the edges, will successfully withstand the impact of a 5-in. duck pin ball, dropped 26 ft. through the air.

Pittsburgh transparent glass tanks are constructed of Herculite plate glass throughout, varying in thickness from ⅝ to 1¼ in. depending on size and service conditions. The bottom has an inner or secondary lining of Herculite white Carrara. Fastenings are of non-corrosive metal, such as Monel metal or stainless steel. Side walls are grooved to take gaskets which are of impregnated glass cloth. Impregnating material varies with the solution to be used in the tank.

Glass-Lined Tanks

The glass-lined tank usually is supplied in a steel shell, although for certain special applications it may be furnished in wood. It is of very rugged construction. The shell is formed from ¼-in. steel plate, continuously welded at all joints with a 3-in. x 3-in. angle, welded around top edge to act as stiffener and base for coping. Where the size of the tank is such that added stiffness is required, an additional 3-in. x 3-in. angle is welded around the tank, slightly below midsection.

The standard tank has a lining of ½-in. Herculite plate glass, held away from the outer shell by special spacers. These spacers are also designed to put compression on the joints that contain glass cloth gaskets. The space between the glass and outer shell contains a continuous acid resistant membrane applied by a process developed by the laboratory.

This type of tank regularly is supplied with replaceable wood coping, but can be furnished of glass at some additional cost, for those jobs where the top edge is not subjected to a great deal of mechanical abuse. The exterior of the tank and the coping receive two coats, for those jobs where the top edge is not subjected to a great deal of mechanical abuse. The exterior of the tank and the coping receive two coats of acid proof enamel before the tank leaves the factory.

While tanks are not ordinarily carried in stock, certain parts are standard, and shipment will be expedited if they are ordered in sizes where all dimensions are multiples of 6 in. Tanks of this type can be furnished only in those sizes up to and including a maximum length not exceeding 12 ft.

All-Glass Tanks

The theoretical maximum size to which an all-glass tank can now be built would be limited by the maximum size in which sheets of Herculite are made. This would be 108 in. x 72 in. x 60 in. No tanks actually have been built up to this maximum size. Glass lined tanks are used where larger sizes are required.

Suitable drains and other fittings have been developed in both porcelain and pyrex. Porcelain drains or outlets are hard-fired and non-porous and can be furnished in sizes having a clear opening of 2 in. and 1 in. Lead drains or outlets are used for photographic work and for other conditions where lead is a suitable material. These are supplied in fittings having clear openings of 1 in. and 1½ in. The outer section has standard pipe threads so that standard fittings may be connected when desired.

The pyrex type drains or outlets are supplied in sizes having clear openings of 1 in., 1½ in. and 2 in. If desired, standard pyrex fittings can be attached to outlets since standard metal flanges are used in assembly.

Tanks are also made with glass hoods for removing fumes and with heaters for controlling temperature. One novel type of heat unit, known as a candle heater, has been developed by Pittsburgh Plate Glass for installations, where it is desirable to have absolute freedom from contamination and to have a unit which will not corrode. These are furnished at varying lengths to conform to the depth of the solution in which they are to be used. One or several may be installed to provide the necessary heat input. Only glass is in contact with the solution, the steam pressure being contained by metal parts inside the glass case with the heat being imparted to the solution by a special heat transfer medium inside the glass tube. One candle heater operating with an 18-lb. steam pressure and immersed to a depth of 25 in. will transfer to water the heat equivalent of 1 kw. (3400 Btu per hour). With a steam pressure of 125 lb., the heat transfer will be about 2.75-kw.

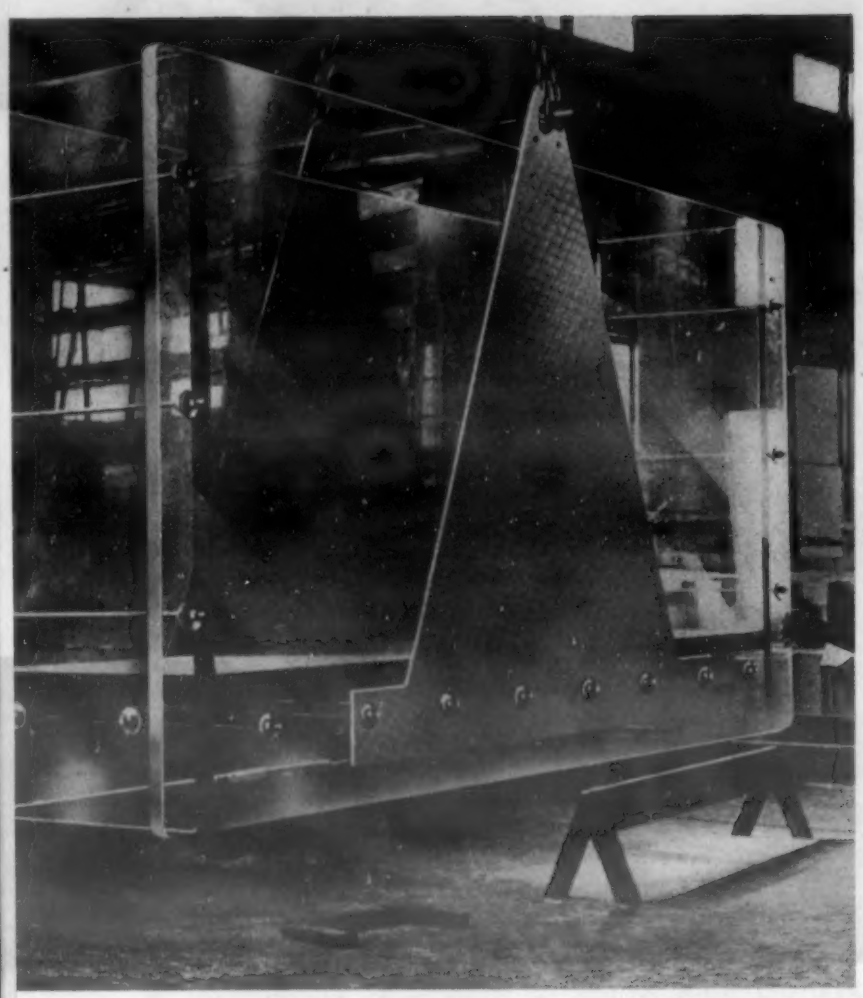
Glass tanks are suitable for use with almost all of the solutions commonly used in the metal industries,

A small glass lined tank for pickling machinery parts.

One of the largest size glass lined tanks. It has a reinforced brick bottom and has seen considerable service in treating copper.

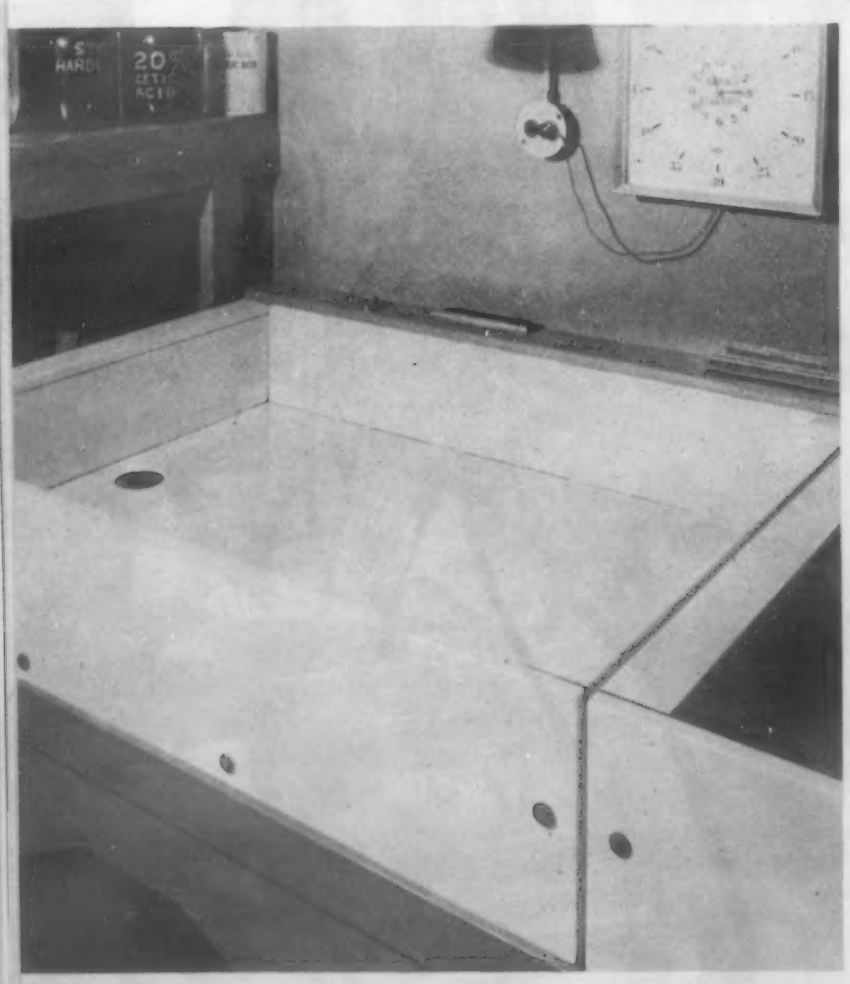
This is one of the toughest tests which a glass-lined tank must undergo—pickling steel rods at high temperatures.

Some electronic parts undergoing electrolytic baths in standard 14-in. square glass tanks.



One of the largest glass tanks ever made. It is consigned for special war work.

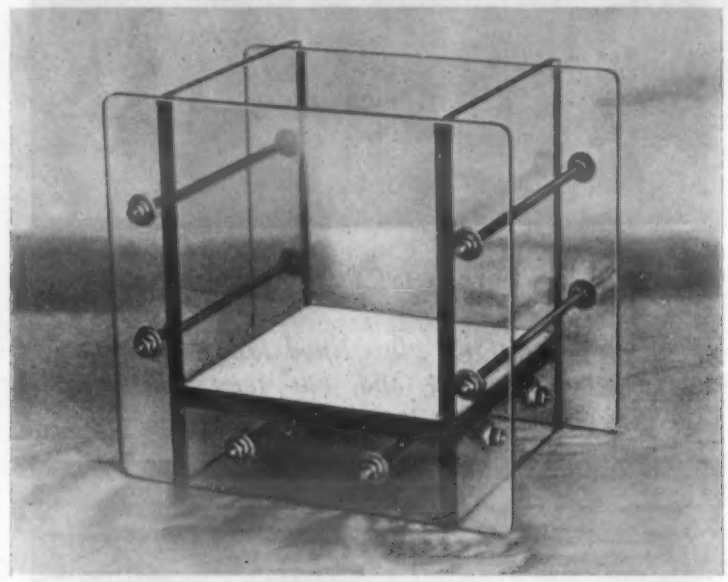
A Herculite Carrara photographer's basin.



including the highly corrosive chromic acid and hot nitric acid, since glass is attacked only by hydrofluoric acid and hot caustic solutions. The material used in the joints is varied with the type of solution to be handled, but little difficulty has been experienced in securing satisfactory materials. Essentially, the ground glass joints may be compared to the ground stoppers used in chemists' reagent bottles. The plastic material is pressed very thin and only its edge is exposed to the solution.

The visibility factor in clear glass tanks has developed some rather novel applications, other than in fields where corrosive solutions are employed. One organization, which tests metal parts for leakage under air pressure in tanks of water, has found glass tanks useful since the tester can watch for air bubbles through the sides of the tank.

Women employed in this work actually prettied up their job by putting goldfish in the tank. Unfortunately, however, contamination from material on metal parts did the goldfish no good.



A transparent glass tank has proved to be a popular size in laboratories. It is flexible but capable of every duty. The binding rods are of Monel metal and the bottom is Carrara lined.

The following are a few of the solutions that are now being handled by glass tanks:

Mineral Acids: Sulphuric acid concentration (66 deg. Baume); hydrochloric acid concentration (22 deg. Baume); nitric acid concentration (42 deg. Baume); aqua regia (1 vol. HNO_3: 3 vol. HCl); chromic acid (up to saturation); acid chromates.

Organic Acids: Acetic acid (up to concentrated); lactic acid up to 50%; oleic acid; tartaric acid.

Pickling and Plating Solutions: Sulphuric acid at 50% concentration and 220 F.; hydrochloric acid 22 deg. Be. at 220 F.; nitric acid conc. 42 deg. Be. 120 F.; nitric acid (14%) plus 8% sod. dichromate 100 F.; sulphuric acid (10%) plus 8% sod. dichromate 120 F.; acid plating solutions containing up to 20% sulphuric acid or hydrochloric acid at temperatures up to 200 F.; chrome plating solution at 120 F.; alkaline plating solutions for copper, gold, silver, tin, zinc; alkaline bleach storage at room temperature; sodium hypochlorite 16%; calcium hypochlorite 5%.

MATERIALS & METHODS MANUAL

3

This is another in a series of Manuals on engineering materials and production methods, published at periodic intervals as special sections in Metals and Alloys. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal-forms or with essential principles, best procedures and operating data for performing specific metal-working processes.

Protective Treatments for Magnesium Alloys

by Jerome L. Bleiweis & A. J. Fusco

Elect Engineering Co., Palisades Park, N. J.

The corrosion resistance of magnesium alloys is a major factor in their selection and service performance. Materials engineers, production men and metallurgists thus have a common interest in the *methods*—either composition control or surface treatment—that can be used to make these alloys better *materials* in this respect. This Manual provides (for the first time anywhere, so far as we know) a correlated review of virtually all the protective surface treatments developed to date, with data on the methods and materials used in each process. In addition detailed and comparative information is given on the techniques and applicabilities of the more common chemical surface treatments and on the plating and painting of these alloys. The inclusion of sections on how magnesium corrodes and on corrosion control by composition-modification make this a compact handbook on improving the corrosion resistance of magnesium alloy products.

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Effects of Composition on Corrosion . . . . Page 433

Metals and Alloys, February 1945

IN RECENT YEARS, the alloys of magnesium have attained widespread use for structural purposes, particularly in aircraft and other fields where weight is an important factor. Magnesium has a specific gravity at 20 C. (68 F.) of 1.74. Consequently alloys of magnesium have been termed "ultralight" alloys.

One of the major problems, confronting the users of magnesium alloys, has been corrosion and its prevention. The existence of this problem could very readily be predicted from the realization of the reactivity of magnesium. Before considering the approach that most investigators have taken to this problem, it would be well to consider, briefly, some basic facts concerning corrosion, generally, and the special case of magnesium, particularly, in order to better understand the direction in which most work has proceeded.

Corrosion of Metals in General

When a metal corrodes the process may be considered to be taking place in two ways. First, the metal may be corroding by the direct chemical attack of its environment. This type of corrosion is exemplified by the action of dry gases, such as oxygen, chlorine, hydrogen sulfide, sulfur dioxide, etc. upon dry metals at ordinary or at elevated temperatures. The second type of corrosion involves the passage of a current from one portion of a metal surface, through a conducting corrosion medium, to another portion of the metal surface, and thence through the main body of the metal to complete the electrical circuit. Many investigators have stated that the first type of corrosion is also electrochemical in nature as the second type obviously is.

The electrochemical theory of corrosion postulates the existence of corrosion cells which are the basic units of the corrosion process. A corrosion cell consists of two electrodes, one of which is capable of functioning as an anode and the other which is capable of functioning as a cathode. The anode may be defined as the electrode to which negatively charged ions flow, and the cathode may be defined as the electrode to which positively charged ions flow. Besides the anode and cathode, the corrosion cell must contain some conducting liquid medium between the two electrodes in which the ions are carried. The cell must be electrically completed by means of a metallic connection between the anode and cathode. Finally there must be a "driving force" or difference of potential which is capable of initiating and maintaining a flow of current throughout the system.

If the surface of a metal, in contact with a conducting environment, exhibits heterogeneity from one point to another, or if the conducting environment on the surface of a metal exhibits any heterogeneity, the requirements for an active corrosion cell are fulfilled, providing the potential difference is large enough to maintain a flow of current.

The driving force which causes a flow of current is considered to be the potential which exists between the metal and the solution at the anode. If a metal tends to dissolve readily in a solution of its ions, it is said to be strongly electronegative or anodic to one which does not exhibit this tendency to dissolve. Actually, of course, this statement can only be tested if the single electrode in contact with a solution of its ions, is electrically connected to another reference electrode immersed in some reference solution because, practically speaking, current can flow only when there are at least two electrodes. *The single electrode potential* is defined as the difference of potential between an electrode and the solution around it when referred to the normal hydrogen electrode whose single electrode potential is arbitrarily chosen as zero.

The values of single electrode potentials are used as the basis for the Electromotive Force Series which is a list of the elements running from the most active or electronegative electrode material, at the top of the list, to the most noble or electropositive material at the bottom of the list. This series is obtained by measuring the potential of an electrode with respect to a one molar solution of its ions referred to the normal hydrogen electrode at 25 C. (77 F.). A condensed series is given in Table I.

Table I.—Electromotive Force Series*

Metal	*Potential Volts*
Lithium	−2.959
Rubidium	−2.925
Potassium	−2.924
Calcium	−2.76
Sodium	−2.714
Magnesium	−1.8
Aluminum	−1.337
Zinc	−0.761
Chromium	−0.557
Iron (ferrous)	−0.44
Cadmium	−0.401
Cobalt	−0.23
Nickel	−0.20
Tin	−0.136
Lead	−0.122
Hydrogen	0.00
Copper	0.344
Silver	0.797
Platinum	0.86
Gold	1.36

* "Handbook of Chemistry and Physics," published by Chemical Rubber Publishing Co., Cleveland

The series presented in Table I is an "idealized" series and is correct under the specific conditions described above. However, from the standpoint of actual corrosion data a more correct "practical" series is the one listed in Table II.[1]

Table II.—Practical E.M.F. Series

Magnesium
Aluminum
Duraluminum
Zinc
Cadmium
Iron
Chromium-iron (active)
Chromium-nickel-iron (active)
Soft solder
Tin
Lead
Nickel
Brasses
Bronzes
Nickel copper alloys
Copper
Chromium-iron (passive)
Chromium-nickel-iron (passive)
Silver solder
Silver
Gold
Platinum

Metals grouped together in Table II have no strong tendency to galvanically corrode each other. Voltage figures are not given in this table because these vary with every new corrosive condition. Relative positions of metals change in many instances when environmental conditions change.

If two of the metals in the E.M.F. series are coupled, the metal higher in the series will act as an anode and protect the metal which is beneath it in the series. The more noble metal acts as the cathode and is protected by the sacrificial solution of the more active metal. This principle is important to consider, when electroplating for the purpose of corrosion protection is undertaken. If a metal such as iron is plated with zinc, the zinc, which is higher in the E.M.F. series, will protect the iron from corrosion in two ways: First, because the "envelope" of zinc excludes the atmosphere from contacting the iron, and secondly, if the zinc coating is discontinuous or porous, it will electrochemically protect the exposed iron pores by causing them to be made cathodic. The influence of the zinc coating may be sufficient to protect an exposed iron section ¼ in. wide.

This galvanic type of protection is desirable when considering the corrosion protection of metals and alloys, for most commercial electrodeposits are somewhat porous, and unless they are anodic to the basis metal, the exposed portions of the underlying metal will corrode. If the coating is more noble than the basis metal, corrosion in the exposed pores will be accelerated and result in "pitting." It may be well to note the position of magnesium in the E.M.F. series. There is no commercially available stable electrodeposit which is anodic to magnesium. The only way to protect magnesium successfully is to enclose it in as nonporous and dense a coating as possible. This applies to electrodeposited magnesium. Even when unprotected, magnesium alloys show excellent resistance in seacoast environments. This may give the reader an indication as to the approach most investigators have taken in seeking methods of protecting magnesium alloys from corrosion.

Polarization and Overvoltage

The values for standard electrode potentials, given in Table I, apply only when no current flows. In any case, however, where there is a flow of current, an opposing or counter electromotive force is developed which may be termed "polarization potential." If the external electromotive force were removed, the counter electromotive force would cause a current to flow in a direction opposite to the initial flow of current caused by the external electromotive force. This counter flow of current is termed polarization current.

Polarization may be divided into two categories, concentration polarization and chemical polarization. The latter is often referred to as overvoltage. Concentration polarization is caused by the concentration change in the electrolyte due to the passage of current. Concentration polarization effects are of approximately the same order of magnitude for most solutions. Consequently, if this were the only type of polar-

ization at work, all metals would manifest approximately the same polarization effects at the same current density. In general, however, the difference between the potential of a working electrode and the same electrode, when no current is flowing is greater than that due to the concentration change in the electrolyte adjacent to the cathode. This additional polarization is called overvoltage.

Table III[2] is a list of the metals arranged in the descending order of their overvoltage values. At the top of the list is zinc which, when exceedingly pure, resists corrosion by moderately strong acids largely because of the difficulty with which molecular hydrogen forms on the zinc surface. At the bottom of the list is the element, carbon, certain forms of which have comparatively low overvoltage values.

Table III.

Zinc	Chromium
Mercury	Gold
Magnesium	Copper
Cadmium	Silver
Aluminum	Iron
Tin	Cobalt
Antimony	Nickel
Lead	Platinum
Bismuth	Carbon

If cathode polarization were complete in any specific instance, current would cease to flow and corrosion would therefore cease too. However, in actual service, the process of polarization is always being counteracted to a greater or lesser degree, depending upon service conditions, by the depolarizing influence of oxygen. The atomic hydrogen in the film which tends to form at the cathode, reacts with dissolved oxygen, which is normally dissolved in the corroding solution, and forms water. This partly removes the barrier to the flow of current, and the corrosion reaction, therefore, proceeds. This type of depolarization is termed oxygen depolarization.

In many industrial applications, dissolved oxygen is removed from solutions where its presence would ordinarily increase corrosion rates substantially by oxygen depolarization. Thus, for example, bisulfite is added to boiler water in order to remove the dissolved oxygen which would accelerate the corrosion of the boiler plates. Where the potential difference existing between the anodic and cathodic areas is sufficiently great to overcome hydrogen overvoltage, molecular hydrogen is deposited and the corrosion reaction proceeds normally without the necessity of oxygen depolarization.

Corrosion Control

The methods which are applicable, in the case of magnesium or any other metal, in order to reduce the tendency to corrode, where the tendency is due to surface heterogeneity or dissimilar metal contact are, obviously, those methods which eliminate these causes. Purer metal, for example, shows a lesser tendency to corrode than metal containing large amounts of impurities.

It may be pointed out that even if the potential difference between two points is great enough to initiate corrosion, the rate factor of the corrosion reaction depends upon the overvoltage and polarization conditions existent in the corrosion cell. Many investigators in the field of magnesium corrosion have discovered that certain elements, if added in small quantities to the alloy of magnesium, result in constituents which, although different in composition from other constituents on the alloy surface, nevertheless, exhibit approximately the same single electrode potential as these other surface constituents.

This "equipotential" surface will probably not exhibit a great tendency to corrode because of the absence of a suitable driving force. The rate of corrosion is reduced by suitable alloying, through the formation of cathodic areas upon which the hydrogen overvoltage is high or by the formation of passivated surfaces whose potentials are reduced through the formation of thin oxide films.

The heterogeneity of the environment results in what is termed a concentration cell. A concentration cell is a corrosion cell in which the electrodes are two points on the surface of a metal or alloy which are in contact with portions of the solution differing in composition. The most important type of concentration cell, and therefore environmental heterogeneity, is the cell which has a different concentration of dissolved oxygen from one portion of the solution to another.

This type of concentration cell is called an oxygen concentration cell. In practice, oxygen concentration cells often are encountered where the initial corrosion reaction causes the formation of porous corrosion products on the metal surface. The underlying metal is then exposed to that portion of the solution which is more deficient in oxygen and it will therefore act as a local anode. The ultimate result is a "pit." Pitting may therefore be attributable to local impurities or to concentration cells (See Fig. 1). The chief cause is local impurities.

Corrosion Behavior of Magnesium

Although magnesium is a very active metal, as its position in the electromotive force series will testify, nevertheless it is resistant to many organic and inorganic substances, in many cases through the formation of protective coatings. Magnesium has, for example, withstood inland environments for periods of many years with very little loss in physical properties, and with a comparatively minor degree of penetration. Although it is not as good as aluminum in this respect, magnesium forms a fairly impervious "self healing" oxide coating in many outdoor environments.

Even in coastal environments magnesium alloy test panels, which were not given any protective surface treatment or coat of paint, were exposed at Point Judith, R. I., at a point within 100 ft. of the Atlantic Ocean. After 5 yrs. of exposure the panels were attacked only slightly. Generally speaking, however, magnesium will corrode much more rapidly in coastal or marine atmospheres than in inland areas. Chlorides are particularly severe in their attack on magnesium, so that in chloride atmospheres (salt water, marine environment, etc.) it is advisable to protect magnesium as well as possible. Prolonged exposure to salt spray results in a bulky non-adherent corrosion product (See Fig. 2).

Alloys of magnesium will not corrode in solutions of chromates, chromic acid, fluorides, borates, or alkalies. Under some conditions, however, these chemicals can produce more or less severe attack. Hydrofluoric acid in concentrations of 10 to 50% will not corrode magnesium, but concentrations under 10% are detrimental. Most other mineral acids attack magnesium vigorously. Table IV[3] is a tabulation of the action of certain chemicals on magnesium alloys from the point of view of the possibility of the use of magnesium in environments of these chemicals.

The foregoing discussion concerning the fundamentals of corrosion reactions and behavior of magnesium explain the approach which has been taken toward making magnesium and its alloys more resistant to corrosion.

Fig. 1. Examples of pitting of magnesium alloys. The corrosion product has been removed by light sandblasting.

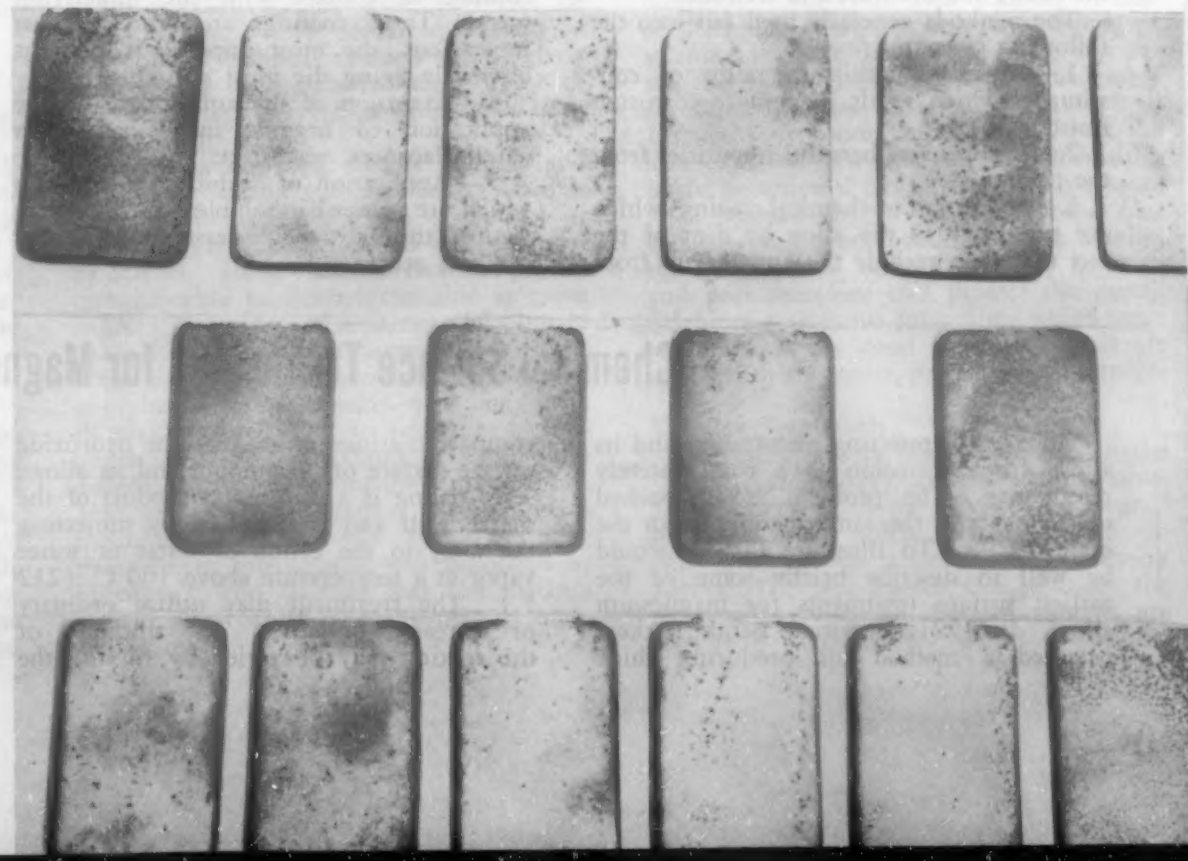


Table IV.—Action of Some Chemicals on Magnesium Alloys

Chemical or mixture	*Concentration (See Note A)*	*Recommended (See Note B)*
Acetic acid	any	no
Acetone	any	no
Acetylene	100%	yes
Alcohol, butyl	100%	yes
Alcohol, ethyl	100%	trial warranted
Alcohol, methyl	100%	no
Ammonium fluoride	any	yes
Ammonium hydroxide	Sp.gr. 0.88	trial warranted
Ammonia gas or liquid	100%	yes
Ammonium salts (most)	any	no
Asphaltum	100%	yes
Alkali metal carbonates	any	yes
Alkali metal bicarbonates	any	no
Alkali metal hydroxides	any	yes
Aniline	100%	trial warranted
Beer	100%	no
Benzene	100%	yes
Bichromates	any	yes
Boric acid solutions	1-5%	no
Borax solutions	1-3%	yes
Butter	100%	no
Bromides	any	no
Calcium salts	3%	no
Carbonic acid (carbonated water)	any	no
Carbolic acid (Phenol)	100%	yes
Carbon bisulfide	100%	yes
Cyanides (most)	any	yes
Carbon tetrachloride	100%	yes
Carbon dioxide	100%	yes
Carbon monoxide	100%	yes
Castor oil	100%	yes
Chlorine	100%	no
Chlorides (all)	any	no
Chromates (most)	any	yes
Chromic acid (pure)	any	yes
Diethylene glycol	100%	yes
Diethylene glycol solutions	any	trial warranted
Ethylene glycol	100%	yes
Ethylene glycol solutions	any	trial warranted
Formaldehyde	50%	trial warranted
Fluosilicic acid	any	no
Fluorine	100%	yes
Fruit acids	any	no
Gas, illuminating	100%	yes
Gasoline (lead free)	100%	yes
Gasoline (leaded)	100%	trial warranted
Grease (acid free)	100%	yes
Hydrochloric acid	any	no
Hydrofluoric acid	10-50%	yes
Hydrofluoric acid	1-10%	no
Hydrogen peroxide	3-30%	no
Hydraulic brake fluids (most)	100%	trial warranted
Heavy metal salts (most)	any	no
Ink (iron)	100%	no
Ink (dye)	100%	yes
Iodides	any	no
Kerosene	100%	yes
Lanolin	100%	yes
Linseed oil	100%	yes
Mercury	100%	no
Mineral acids (dilute)	any	no
Mineral acids (concentrated): Fuming HNO_3 and fuming H_2SO_4 or mixtures of same have no action on magnesium but their use is not recommended	—	—
Milk	100%	no
Nitrates (most)	any	no
Oil, vegetable (chloride free)	100%	yes
Oil, mineral (chloride free)	100%	yes
Oil, animal (acid free and chloride free)	100%	yes
Oxygen	100%	yes
Organic acids	any	no
Phosphates (most)	any	yes
Phosphoric acid (H_3PO_4)	any	no
Potassium fluoride	any	yes
Permanganates (most)	any	yes
Potassium hydroxide	any	yes
Phenol (carbolic acid)	100%	yes
Rubber cement	100%	yes
Salt (sodium chloride)	any	no
Sea water	100%	no
Sulphur	100%	yes
Sulphates	any	no
Sodium carbonate	3%	yes
Sodium silicate (water-glass)	any	yes
Sodium hydroxide	any	yes
Sodium fluoride	any	yes
Steam	100%	no
Tar	100%	yes
Tung oil	100%	yes
Turpentine	100%	yes
Vinegar	any	no
Water (distilled, $\leq$100 F.)	100%	yes
Water (distilled, $>$100 F.)	100%	no
Water (tap)	100%	no

Notes:

A. Concentrations other than 100% refer to water solutions. The recommendations refer to performance at room temperature only, unless the temperatures are specified.

B. The recommendations given in this column are based either on practical experience or on laboratory experiment, and should serve only as a guide. Because service conditions may vary so much, different results may sometimes be obtained; for example, impurities known or unknown, in the chemicals involved may cause corrosion. For these reasons this table should serve only as a preliminary guide and, unless the application is a well established one, trial should be made before any substantial application is undertaken. In some cases, the application of a suitable protective coating permits the use of magnesium in contact with materials which might attack the bare metal.

Increasing the Resistance to Corrosion

The methods generally used fall into the following categories:

1.—Inclusion within the alloy of constituents which result in a more corrosion resistant alloy.

2.—Exclusion of harmful impurities from the composition.

3.—Formation of chemical coatings which are protective to the alloy by dint of the fact that they exclude the atmosphere from coming in contact with the underlying metal. These coatings are more or less impervious, the most impervious coatings obviously being the most desirable.

4.—Exclusion of the atmosphere by the application of organic finishes such as paints, lacquers, waxes, etc.

5.—Application of "inhibiting" coatings which are somewhat soluble and offer protection through their passivating or inhibiting action.

Any combination of these types of treatments are used. For example, a special corrosion resistant alloy may be produced chemically coated, primed, and painted. In this manner a maximum amount of corrosion resistance is obtained. This procedure is not feasible in all cases, however. The sections that follow will discuss the various methods individually, starting with the chemical treatments and finishing with control of alloy composition.

Chemical Surface Treatments for Magnesium

The art of protecting magnesium and its alloys from corrosion is a comparatively recent one. The problem is approached today in about the same manner as in the early 1920's. To illustrate this, it would be well to describe briefly some of the earliest surface treatments for magnesium alloys. In 1921, Christian Bergh Backer[4] patented a method for producing thick compact coatings of magnesium hydroxide on the surface of magnesium and its alloys. The coating is a conversion product of the metal itself and is produced by subjecting the alloy to the action of water or water vapor at a temperature above 100 C. (212 F.). The treatment may utilize ordinary or increased pressures. The thickness of the coating may be varied by varying the processing conditions as follows:

1.—Heating magnesium articles in an autoclave under a steam pressure of 10 atmospheres for 15 min. produced a coating approximately 1.5 mm. thick.

2.—Immersion of magnesium articles in boiling water at 5 atmospheres pressure required 1 hr. to produce a coating approximately 0.2 mm. thick.

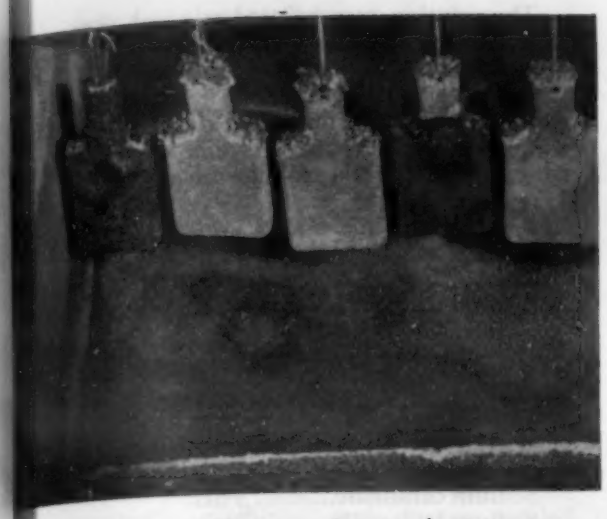


Fig. 2. Bulky corrosion product on magnesium alloy test panels exposed to salt spray.

The coating produced is fairly hard and adherent and will impart some corrosion resistance to magnesium alloys although in this respect it does not compare with some of the more modern treatments. The coating is not particularly suitable as a paint base either; this is an important factor to consider in chemically surface treating magnesium alloys. The reason for its unsuitability is that magnesium hydroxide is soluble in moisture and forms an alkaline solution which attacks paint resulting subsequently in paint peeling. However, one of the advantages of the coating is in its ability to absorb readily and to act as a mordant for dyes. It, therefore, has application for ornamental purposes.

Another early method devised for the protection of magnesium alloys is that due to E. Wollner and F. Thomas.[5] Their method relates to a process of producing magnesium oleate or resinate coatings on magnesium alloys by protracted treatment in an oil-water-soap emulsion. The coating produced is somewhat more elastic than the ordinary oxide coating and may be produced in a variety of colors by adding suitable dyes to the treatment bath. One suitable formula is an emulsified mixture containing by weight:

2 parts of soap
3 parts of linseed oil
100 parts of water.

The oleate formed will vary in thickness, depending upon the duration of the treatment, from about 0.01 mm. to 1.0 mm. or greater.

Coloring Magnesium

One of the early treatments for coloring magnesium and its alloys is the one due to F. Thomas.[6] The methods described produce brown, horn, brass, or an etched black on magnesium alloys according to the following methods:

I—*Brown Coloring of Magnesium Alloys Containing 3 to 8% Zinc:* The object to be colored is cleaned and suspended in a bath containing:

350 grams of sodium dichromate
94 grams of copper nitrate
100 milliliters of C.P. nitric acid (sp. gr. 1.36) and
9500 milliliters of water.

The objects are moved about in the bath, maintained at 85 to 90 C. (185 to 194 F.) for from 20 sec. to 3 min., after which they are immediately rinsed in cold running water, immersed for a few seconds in clean boiling water, and dried in hot air. The intensity of the color may be increased by coating the surface with grease or oil.

II—*Horn Coloring of Magnesium Alloys:* The solution used is made up as follows:

180 grams of sodium dichromate
133 grams of manganese sulfate
20 milliliters of nitric acid (sp. gr. 1.36), and
water to make 5 liters.

The bath is used cold, and the treatment requires a 1-min. immersion. The immersion is followed by a thorough cold water rinse and a subsequent hot water rinse.

III—*Brass Coloring of Magnesium Alloys:* The solution used is made up as follows:

180 grams of sodium dichromate
35 grams of ferrous nitrate
2.5 milliliters of nitric acid (sp. gr. 1.36) and
water to make 5 liters.

The cleaned articles are suspended in the cold bath for 30 sec. to 1 min. and rinsed first in cold water and then in hot water.

IV—*Black Etching of Magnesium Alloys:* The solution used is made up as follows:

37.5 grams of sodium dichromate
123 milliliters of nitric acid (sp. gr. 1.36) and
water to make one liter.

The bath is used cold. The objects are dipped into the bath, kept in constant movement, removed after a few seconds, and when the adherent liquid of the bath no longer reacts with the metal, the objects are thoroughly rinsed with water. The reaction is complete when the evolution of gas is no longer visible. After drying, the articles may be coated with a film of oil or colorless lacquer. Heating to 300 to 400 C. (572 to 752 F.) will further darken the etch.

It might be well to note, at this point, that the present widely used "Chrome-Pickle" treatment, which will be discussed in detail later, is merely another modification of the treatments described by Thomas.

Other Chemical Treatments

The first fluoride coatings for magnesium and its alloys were produced by Keeler.[7] The electrolyte used was a 48% solution of hydrofluoric acid, and the coating is produced either by immersion or anodically. The fluoride coating produced is very white and matte. Fluoride coatings are widely used today as preliminary steps in coating magnesium. The Dow No. 7 and 8 treatments are the outstanding examples.

Many other specific treatments can be described, but such a description would be too lengthy. Instead, examples will be given of chemical treatments from the point of view of the active reagents which have been widely used.

Impregnation with soluble silicates and subsequent baking was devised by Daniels and Zimmerman.[8] The use of phenol or phenol containing compounds was suggested by Michel.[9] He stressed the fact that phenol coatings were particularly suitable as paint bases. The first phosphate and borate coatings for magnesium appeared in 1928[10] when immersion treatments in solutions of phosphoric or boric acids were suggested. Burdick[11] made use of an acid salt of phosphoric acid such as sodium or magnesium dihydrogen phosphate for the same purpose. The use of permanganate together with hydrofluoric acid, acetic acid, hydrogen peroxide, or dichromates was suggested by Sprenger[12] who claimed that the coatings formed were oxides of manganese or manganese itself.

Alkaline solutions of metallic salts such as vanadates, molybdates, tungstates, titanates, uranates, manganates, etc. were suggested by Boulanger.[13] The coatings are formed by immersion or by anodic treatment in the solutions of the reagents listed above. One of the earliest dichromate[14] treatments was that relating to the use of a dichromate acidified with an acid other than hydrochloric. The acid which is preferred is nitric acid. The iridescent coating formed serves as a good paint base for magnesium alloys. This treatment is the forerunner of the widely used "Chrome-Pickle" treatment.

A later treatment embodying dichromates which could be used without any serious attack on magnesium alloys was developed in 1929.[15] According to this process, the magnesium parts are immersed in a heated neutral or acid bath containing chromates and dichromates of an alkali metal plus a salt or compound of aluminum. Neutral and acid baths are to be preferred to alkaline solutions for they form coatings which are more suitable as paint bases than the alkaline solutions. Dichromates used together with manganese salts were proposed in 1929.[16] It is claimed that dark brown or black oxide coatings containing MnO_2 are formed by immersion in a neutral solution containing a salt of bivalent manganese such as $MnSO_4$ and a water soluble chromate or dichromate. Heating at elevated temperatures for a short time darkens the film formed.

Treatments embodying the uses of chromates or dichromates are the most widely used treatments today for the surface finishing of magnesium alloys. The first selenium treatments were devised by Bengough and Whitby.[17] These treatments represented a radical departure from the then existing methods which utilized chromates and dichromates as the basis for most coating processes. In their process, an aqueous solution of selenious acid was used as the treatment bath, or a solution of a soluble selenite may serve alternatively. With the selenium compound there is included a salt corrosive to magnesium such as sodium chloride.

The inventors relate some of their experiences with selenium coatings in a later article.[18] Light magnesium alloys containing 88 to 98% Mg were immersed in an aqueous solution containing 10% H_2SeO_3 and 0.1 to 0.5% sodium chloride at room temperature for from 5 to 10 min. A film of selenium (and probably compounds of selenium) about 0.002 mm. thick was deposited. This coating afforded considerable resistance to a sea water spray during 8 to 12 weeks exposure. It is claimed that the film exhibited the property of self-healing in the presence of moisture. For this reason, it is claimed that if damage to the film should result from handling or in service, the coating will reform, partially at least, and will therefore still protect the metal. Selenium treatments form films which serve as comparatively good paint bases and are used for this purpose, particularly in Europe.

The Dow Treatments

The most widely used treatments in the United States, today, are the various processes designated as the "Dow Treatments." Most of them utilize chromates and dichromates as the active coating forming agents. The best known and probably the most widely used of these treatments are the Dow Treatments No. 1 (Chrome-

Pickle), No. 7 (Dichromate), and No. 8 (Modified Alkaline-Dichromate). These treatments will be discussed in detail in the next section, and later it would be well to summarize and discuss briefly the other processes which have been used and many of which are still being used particularly for special purposes for which they may be particularly applicable. They have been designated as indicated in Table V.

Table V.—Designations for Dow Treatments

Dow Treatment No.	*Name of Treatment*
2	Chrome-phosphate
3	Alkaline-dichromate
4	Chrome-alum
6	Caustic-pressure
9	Galvanic anodize
10	Sealed chrome-pickle
11	Chrome-sulfate
12	Caustic-anodize
13	Anodic

Pretreatment and Cleaning

A very important part of magnesium coating processes is the pretreatment stage. The pretreatment stage refers to that surface treatment applied to the article before entrance into the coating bath proper. The function of the pretreatment is to prepare the surface in a manner which will make it most receptive to the coating process. This is done by first removing all grease, oil, and loosely held foreign matter and secondly by removing obdurate oxide skins which may impede the coating process.

For the removal of large amounts of grease or oil, the most effective and economical method involves the use of solvent cleaning or vapor degreasing. The ordinary commercial degreaser, employing stabilized chlorinated solvents such as trichlorethylene, is satisfactory for this purpose. An alternative method of precleaning involves the use of emulsion cleaners. These cleaners are composed essentially of a mineral distillate such as kerosene and an emulsifier or an oil soluble soap. The articles are immersed in the emulsion cleaner or the cleaner is force sprayed at the parts for 3 to 5 min., the cleaner temperature being maintained at about 150 F. This is followed by a thorough water rinse or spray.

The precleaning treatments just described will eliminate most of the oil and grease but for most effective cleaning some type of alkaline cleaning should follow the solvent or emulsion step. The alkaline type cleaner has the added advantage of being an excellent "stripper" for "chrome-pickle" coatings which should generally be removed prior to any further chemical treatment. Generally speaking a strong alkaline cleaner, similar to the type used for steel, will be satisfactory for magnesium. One suitable formula is the following:

Trisodium phosphate.... 4 ozs.
Sodium carbonate..... 4 ozs.
Soap..... 0.1 ozs., and
Water..... to make 1.0 gal.

The solution may be used as a soak or as an electrolytic cleaner. As a soak cleaner, the bath should be operated at the boiling point although 180 F. with agitation is a satisfactory lower limit. The cleaning time should be about 5 to 15 min. For electrolytic cleaning the conditions are as follows:

Work..... cathode
Temperature..... 160 to 180 F.
Current density. 10 to 20 amp. per sq. ft.
Time..... 1 to 5 min.

If the bath is operated as an electrolytic cleaner it is desirable to omit the soap. Another satisfactory soak cleaner is the following:

Sodium carbonate..... 3 ozs.
Sodium hydroxide..... 2 ozs.
Soap..... 0.1 ozs. and
Water..... to make 1 gal.

The bath is operated at the boiling point for a few minutes and then the work is thoroughly rinsed and dried. The amount of surface etching resulting from these alkaline cleaners is slight. Increasing the caustic soda content minimizes it still further.

Oxide coatings, dirt, etc. may be removed mechanically by wire-brushing, sanding, sand-blasting, or shot blasting or chemically by acid pickling. Sand-blasting or shot blasting should always be followed by acid pickling because they reduce the corrosion resistance of the alloy through contamination by electropositive substances resulting in galvanic corrosion. A satisfactory pickling procedure utilizes a solution containing 8 parts of concentrated nitric acid, 2 parts of concentrated sulfuric acid and 90 parts of water. The articles are immersed for 10 to 20 sec. in the solution maintained at room temperature.

Pickling should be followed by very thorough water rinsing. A non-etching acid pickle which will readily dissolve magnesium oxide or hydroxide as well as various drawing and forming lubricants without attacking magnesium may be prepared by dissolving 1.5 lbs. of chromic acid in enough water to make 1.0 gal. of solution. The bath is used at 190 to 212 F., and the time of immersion will vary from about 1 to 20 min. This treatment has one disadvantage. Articles treated by anodic processes such as Navy PT-13 do not coat well after chromic acid pickling. Pickling before chemical treatment definitely enhances the protective value of the chemically coated article.

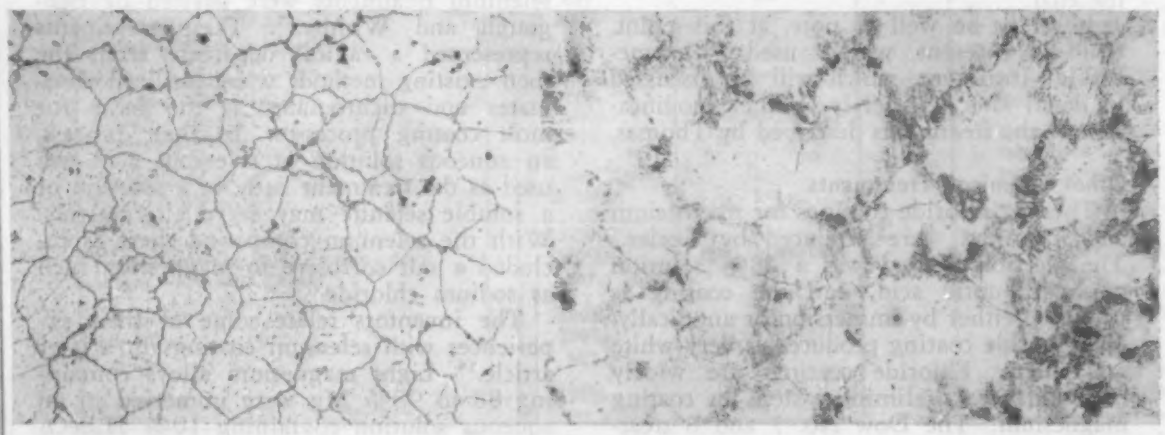


Fig. 3. Solution treated structure (left) and solution-treated-and-aged structure (right). The dark shadows in grain boundaries in the right-hand photo are Mg_2Al_3.

The Dow Treatments

Chrome-Pickle Treatment

The "Chrome-Pickle" treatment (Dow Treatment No. 1) is probably the most widely used chemical surface treatment in this country for magnesium alloys. This stems from the fact that it is the simplest and most rapid of all the chemical treatments for surface coating magnesium. The primary purpose of the chrome-pickle treatment is to afford corrosion protection to rough castings, sheet, extrusions and forgings during storage, shipment, and machining. However, the treatment may be used as a weld cleaner and is being used to a large extent as a base for paint on surfaces whose dimensions are not held too close to tolerances. Etching occurs during the treatment and as much as 0.0006 to 0.001 in. of metal per surface may be removed during the treatment. For machined surfaces a modified chrome-pickle solution may be used. This will be described below.

Before chrome-pickling, the articles should be suitably cleaned and pretreated as described previously under "Pretreatment." They are then immersed in either of the two following treatment baths:

Sodium dichromate
($Na_2Cr_2O_7.2H_2O$)..... 1.5 lbs.
Nitric acid
(HNO_3– Sp. Gr. 1.42).. 1.5 pints, and
Water..... to make 1 gal.

or for finish machined parts:

Sodium dichromate
($Na_2Cr_2O_7.2H_2O$)..... 0.75 lbs.
Nitric acid
(HNO_3– Sp. Gr. 1.42).. 0.50 pints, and
Water..... to make 1 gal.

The time of immersion is ½ to 2 min. for unmachined parts or raw castings and 15 sec. for finish machined parts. The baths should be maintained at 70 to 90 F. After immersion, the articles are held above the bath and allowed to drain for 5 sec. and are then thoroughly rinsed in cold water followed by a hot water rinse to facilitate drying. The dimensional loss resulting from the 15-sec. treatment in the modified bath is negligible. Either solution should be

held in either earthenware, aluminum, or stainless steel tanks.

It should be noted that, since most raw castings are chrome-pickled in the higher concentration bath, finish machined castings will have been chrome-pickled twice for they will be treated in the lower concentration bath as well. The only surfaces which will not receive two treatments will be the machined surfaces, but since machined surfaces are naturally more corrosion resistant than rough surfaces, treatment in the modified solution will suffice in providing adequate corrosion protection in most cases.

The chrome-pickle coating has a low electrical resistance and is therefore desirable on mating portions of machined articles where electrical conductivity is desirable. Chrome-pickled raw castings which are eventually machined and chrome-pickled again in the modified bath should not be alkaline cleaned or pickled before the second treatment because either alkaline cleaning or acid pickling will remove the first coating. Thorough vapor degreasing after machining will usually suffice as a pretreatment previous to processing finish machined parts.

Chrome-pickling magnesium alloys provides a whole host of color effects on the surface of the alloy. The colors range from matte, gray to yellow-red iridescent coatings showing a pebbled etch under the microscope through coatings having bright red tints together with green shades and further through bright brassy colored surfaces which are comparatively smooth when viewed under the microscope to bright silvery coatings.

The color, luster, and etch produced vary with the age of the solution and with the type of heat treatment of the alloy. The latter factor will be considered further on. "Worked" baths which yield iridescent yellow red coatings in a solution containing 1.5 lbs. of sodium dichromate and 1.5 pints of nitric acid per gal. of solution will yield coatings of the type listed in Table VI upon the indicated changes in composition.

Table VI.—Color of Chrome-Pickle Coatings

Condition of Bath	*Nature of Coating*
New baths containing 1.5 lbs. of sodium dichromate and 1.5 pints of nitric acid per gal. of solution	Matte gray deposits showing little iridescence. Deposits are sometimes powdery.
Worked bath of above composition	Coatings may be matte or bright red, red-violet, golden-yellow, red-yellow or red-yellow with green streaks.
Worked bath containing up to about 3 pints of nitric acid per gal.	Greener coatings becoming brassy colored and less green as the HNO_3 content approaches 3 pints per gal.
Worked bath containing over 3 pints of nitric acid per gal.	Bright brassy to bright silvery colored coating.

Increasing the dichromate content increases the tendency toward red, but this tendency disappears in baths containing more than 3 pints of nitric acid per gallon. Additions of ammonium molybdate decrease the iridescence of the coating and cause it to be more powdery. The colored coatings are very pleasing to the eye and have a high degree of sales appeal. The color and appearance of the coating may also be a guide to the corrosion resistance properties or paint base qualities of a particular coating. Table VII is a comparison of these qualities for various chrome-pickle coatings.

Table VII.*—Color and Quality of Chrome-Pickle Coatings

Color of Coating	*Quality of Coating*
Matte gray	Less corrosion resistance than colored coatings. Good paint base.
Yellow-red iridescent	Good corrosion resistance. Very good paint base. Best all around coating.
Smooth brassy coating	Best corrosion resistance of all coatings. Poor paint base.
Silvery coatings	Poor corrosion resistance. Poor paint base.

* The words good, poor, best, etc. are used for comparative purposes with other chrome-pickle coatings, not with other types of chemically produced coatings.

Generally speaking, it may be stated that the chrome-pickle treatment offers considerable protection in normal inland or in excessively humid atmospheres. In salt water or salt spray environments, however, although some corrosion protection is obtained, the degree is not considerable. Acid pickling before chrome-pickling increases the corrosion resistance of chrome-pickled raw castings or sand blasted surfaces.

Sometimes difficulty may be obtained in chrome-pickling sand or permanent mold castings which have been solution heat treated and aged and almost always in chrome-pickling die castings. The difficulty manifests itself in the form of a powdery dark surface film completely obscuring the normally colored surface. The film is merely the interstitial Mg_3Al_2 component which precipitates in the grain boundaries of aged castings containing aluminum or in die castings (See Fig. 3).

The powder may be brushed away and the surface of the casting will not be impaired so far as paint receptive qualities are concerned. The Mg_3Al_2 constituent is not readily attacked by the nitric acid of the bath and therefore appears as a surface powder when the magnesium rich matrix has been dissolved. Various methods may be employed to minimize this condition. They are especially applicable to die castings. The normal bath or one containing

Chromiumtrioxide (CrO_3) ..... 1.0 lbs.
Nitric acid (HNO_3 Sp. Gr. 1.42) ..... 0.9 pints, and
Water ..... to make 1 gal.

may be used at 50 C. (122 F.) for a treatment time of 5 to 10 sec. or small amounts of a fluoride or hydrofluoric acid may be added to the chrome-pickle bath in quantities sufficient so that the rate of attack of the HF formed, on the Mg_3Al_2 constituent equals the rate of attack of the HNO_3 upon the magnesium rich matrix.

A third method which has proven highly successful and beneficial employs the use of a 5-min. immersion in a 15% HF solution before a 15-sec. chrome-pickle. This treatment increases the corrosion resistance of the coating. The coating produced is not marred by the powdery film, but it is duller than the normal iridescent coating.

The Dichromate Treatment

The "Dichromate" treatment (Dow Treatment No. 7) is the most widely used final treatment for magnesium alloys where maximum salt water corrosion resistance or a highly corrosion resistant paint base is desired. Articles to be treated are pretreated according to the methods described under "Pretreatment" previously discussed. They are then immersed in a water solution containing 15 to 20% of hydrofluoric acid by weight. The time of immersion is 5 min., and the temperature is maintained at 70 to 90 F. The hydrofluoric acid is most suitably contained in a lead lined tank.

The articles are thoroughly rinsed in cold running water and are then immersed in a boiling 10 to 15% by weight solution of sodium dichromate for 45 min. They are thoroughly rinsed in cold water and finally in hot water to facilitate drying. The hydrofluoric acid dip serves the purposes of "homogenizing" the surface, *i.e.* dissolving surface impurities such as iron, aluminum rich constituents, silica, etc. and also forms an insoluble, absorptive, corrosion resistant film of MgF_2 which subsequently absorbs or adsorbs dichromate (according to some authorities it has an activating or catalytic effect) forming a dark brown to black coating on the surface of the article.

The dichromate treatment has the following attributes:

1.—It affords the most salt water corrosion resistance of any of the Dow treatments for magnesium and its alloys (See Fig 5).

2.—It provides a very fine corrosion resistant paint base for magnesium and its alloys.

3.—Negligible dimensional changes are effected in this treatment making it very valuable for finish machined parts.

4.—Inserts of brass, bronze, and steel are not affected by the treatment although aluminum and cadmium plate are attacked by the hydrofluoric acid solution.

Fig. 4. This sand-cast crankcase housing for an aircraft engine has just been given a dichromate dip. (Courtesy of American Magnesium Corp.)

5.—Very little reagent depletion occurs during the process. Most of the solution losses are due to dragout.

6.—The process is very easily operated and does not require the use of electrical current and its attendant difficulties.

Modified Alkaline-Dichromate Treatment

This treatment, also known as the Dow Treatment No. 8, is also very valuable as a final chemical treatment for magnesium and its alloys. It is almost as resistant to salt water corrosion as the dichromate treatment and forms a coating which is harder and more abrasion resistant. The procedure employed follows:

1.—The articles to be treated are suitably pretreated as described previously under "Pretreatment."

2.—As in the dichromate treatment, the articles are immersed for 5 min. in a 15 to 20% by weight solution of hydrofluoric acid.

3.—They are rinsed in cold water and immersed for 45 min. in a boiling solution containing

Ammonium sulfate $(NH_4)_2SO_4$	4 ozs.
Sodium dichromate $(Na_2Cr_2O_7.2H_2O)$	4 ozs.
Ammonia (sp. gr. 0.88)	⅓ fl. oz., and
Water	to make 1 gal.

4.—The articles are again rinsed in cold water and then immersed for 5 min. in a boiling solution containing 1% by weight of arsenious oxide (As_2O_3).

5.—Finally the parts are rinsed in cold water again and then in hot water to facilitate drying.

The coating produced ranges from dark gray to black in color and, as in the case of the dichromate treatment, no dimensional changes occur. The same advantages which apply to the dichromate treatment apply to the modified alkaline dichromate treatment as well. However, it is not used as frequently as it employs a more complex solution and requires an additional step not required by the dichromate treatment.

The remaining Dow treatments are cursorily summarized in Table VIII.

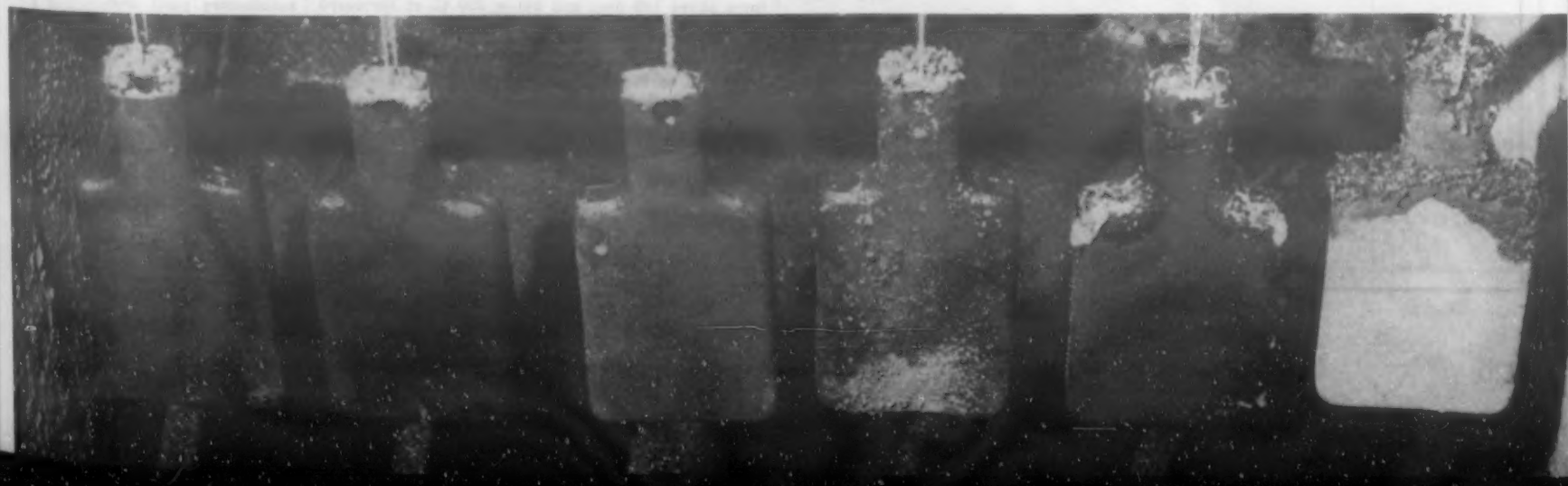
Table VIII. Dow Treatments Other Than Chrome-Pickle, Dichromate and Modified Alkaline Dichromate Treatments

Name of Process	*Dow No. 2 (Chrome-Phosphate)*	*Dow No. 3 (Alkaline-Dichromate)*	*Dow No. 4 (Chrome-Alum)*	*Dow No. 6 (Caustic-Pressure)*
Purpose	To provide a protective coating and suitable paint base for magnesium and magnesium alloys.	To provide a protective coating and also a suitable paint base for magnesium alloys.	The purpose of this chemical treatment is to provide a decorative black finish on die castings of the Dowmetal K or R type.	To provide a corrosion resistant finish capable of being dyed on magnesium and its alloys.
Nature of Coating	The coating is a dark gray to black in color, the color produced being darker with increasing aluminum content of the alloy.	The coating may range in color from gray to black. Machined surfaces tend to show darker coatings than sand-blasted surfaces which usually assume a dark gray as their final color.	A properly applied coating is black and consists of a smooth compact layer adhering firmly to the surface.	The coating produced is light gray or bronze in color and is hard and abrasion resistant. It is composed essentially of magnesium hydroxide.
Treatment Procedure	1. The parts to be treated are thoroughly cleaned by means of alkaline cleaning or vapor degreasing. 2. Oxide films may be removed prior to treatment by sandblasting, pickling, wire brushing, etc. 3. The parts are then immersed for 15 to 20 min. in a boiling or close to boiling solution composed of: Sodium dichromate $(Na_2Cr_2O_7.2H_2O)$ ..... 1 lb. Monobasic sodium phosphate $(NaH_2PO_4.H_2O)$ ..... 1 lb. Water ..... to make 1 gal. 4. The articles are then washed in cold water followed by a hot water rinse to facilitate drying.	1. The parts to be treated must be thoroughly cleaned by vapor degreasing or preferably with an alkaline cleaner. 2. Oxide films may be removed by sand-blasting, pickling, wire brushing, etc. 3. The parts are then immersed for 20 to 60 min., or until they are dark gray or black, in a boiling solution containing: Ammonium sulphate $(NH_4)_2SO_4$ ..... 4 oz. Sodium dichromate $(Na_2Cr_2O_7.2H_2O)$ ..... 4 oz. Ammonia (Sp.Gr. 0.880) ..... ⅛ fl. oz. Water ..... to make 1 gal. 4. The articles are then immediately washed in cold running water followed by a hot water rinse to facilitate drying.	1. The parts to be treated are cleaned by vapor degreasing, alkaline cleaning or both. 2. Oxide films may be removed previous to treatment by sandblasting, pickling, wire brushing, etc. 3. The parts are immersed in a boiling solution composed of: Potassium chrome-alum $(K_2Cr_2(SO_4)_4.24H_2O)$ ....4 oz. Sodium dichromate $(Na_2Cr_2O_7.2H_2O)$ .....13.3 oz. Water ..... to make 1 gal. 4. The time of treatment ranges from 2 to 15 min. depending upon the freshness of the solution. 5. The articles are finally thoroughly rinsed in cold water, followed by a hot rinse to facilitate drying.	1. The articles to be treated are first suitably cleaned and pickled. 2. They are then immersed in the treatment solution which is contained in an autoclave. The solution is the following: Sodium hydroxide .....13.3 oz. Water—to make 1 gal. Operating conditions are: Temperature—392 F. Pressure—225 p.s.i. Time—3 to 5 min. 3. The treated parts are removed, rinsed in running cold water and finally dipped in hot water to facilitate drying.
Notes and Comments	1. The dimensional change of the surface treated is negligible. 2. The processing tank should be lead lined and heated with lead lined steam coils. 3. Loose powder left on the surface after treatment should be removed. 4. This treatment has been largely superseded by the Dow No. 3, Alkaline Dichromate Treatment.	1. This treatment is not intended as a replacement for the Chrome-Pickle Treatment but is recommended as an alternative for those cases in which dimensional changes are to be kept at a minimum. No dimensional losses result from this treatment but dimensional gains up to 0.0003 in. on a surface may result. 2. This treatment may be applied to some alloys as a black decorative finish. 3. The coating solution may be controlled and revivified by maintaining the pH between 5.6 and 6.2 by additions of chromic acid (CrO_3) and sulphuric acid (H_2SO_4 conc.) in equal proportions by weight. 4. The color of the coating or decorative effect is dependent upon the composition and state of the alloy and on the pretreatment or cleaning. The color, however, has only a slight bearing on the paint base quality, as the gray and black coatings are approximately equivalent from this standpoint. 5. Dowmetal K or R die castings do not color uniformly except on machined surfaces. Pure magnesium and Dowmetal M do not color appreciably in the alkaline-dichromate solution. The treatment has little value for these materials. 6. When applied to articles which are partially or entirely chrome-pickled, some darkening of the chrome-pickle area will occur. It is not necessary to remove the chrome-pickle finish prior to the application of the Alkaline-Dichromate treatment if the article is to be painted. 7. Dowmetal castings or other parts containing steel or brass inserts may be given the Alkaline-Dichromate treatment without affecting machined surfaces or the inserts. 8. The coating solution may be used in aluminum or steel tanks.	1. The finish has slight protective value and is suitable for mild indoor exposure, but is not recommended alone for prolonged outdoor exposure or severe service. 2. It is claimed that the finish serves as a base for paint and improves the adhesion and durability of the paint coating. 3. Treatment in a depleted chrome-alum solution results in a superficial layer of brown powder which may be removed by wiping, or tumbling in sawdust or other suitable material. 4. The solution may be revivified by additions of small quantities of sulphuric acid, not exceeding 2.5 ml. of conc. H_2SO_4 per liter (⅛ fl. oz. per gal.) or sufficient to just redissolve, on boiling, the brown precipitate which settles out during the treatment. 5. The need for revivification is indicated by pale colors on the metal and the presence of quantities of a brown sediment in the solution and on the work.	1. The coating produced is more resistant to salt water corrosion than the chrome-pickle coating. 2. Steel, brass, and bronze inserts, are not affected by the treatment, but aluminum is severely attacked. 3. The coating is alkaline in nature and is therefore not very suitable as a paint base. 4. Many decorative colors can be obtained by either adding water soluble organic dyes to the treatment bath or by supplementing the coating treatment with a 10-min. immersion in a boiling solution containing the dye and an etching agent such as very dilute acid or a salt slightly acid by hydrolysis.

Table VIII. (continued)

Name of Process	*Dow No. 9 (Galvanic Anodize)*	*Dow No. 10 (Sealed Chrome-Pickle)*	*Dow No. 11 (Chrome-Sulphate)*	*Dow No. 12 (Caustic-Anodize)*	*Dow No. 13 (Anodic Treatment)*
Purpose	To provide a protective coating and a superior paint base for magnesium and magnesium alloys, particularly the magnesium-manganese type of alloy.	To increase the corrosion resistance of chrome-pickled magnesium or magnesium alloys.	To provide a protective coating, having low electrical resistance, for magnesium alloys and particularly for wrought alloys such as Dowmetal M.	To provide a protective coating, which can be dyed for magnesium and its alloys.	To provide a corrosion resistant coating, which is suitable as a paint base.
Nature of Coating	Properly applied coatings will be uniform and black in color.	The sealed chrome-pickled coating is no different from the ordinary chrome-pickled coating in color or appearance. There is, however, additional absorption of chromates and dichromates in the pores of the coating.	A properly applied coating on Dowmetal M will be uniform and brassy. The other alloys assume a brown to black color.	The coating is neutral in color and highly absorptive. It is composed essentially of magnesium hydroxide and is fairly hard and abrasion resistant.	The coating produced is dark, particularly on sand and permanent mold castings upon which the coating may be black. Die castings yield coatings which are grayer in color.
Treatment Procedure	1. The parts to be treated are thoroughly cleaned by means of vapor degreasing or preferably by alkaline cleaning. 2. Heavy oxide films may be removed by sand-blasting, pickling, wire-brushing, etc. 3. The parts are immersed for 5 min. in a water solution containing 15 to 20% by weight of hydrofluoric acid at room temperature. 4. The articles are then thoroughly rinsed in cold running water. 5. They are then immersed and galvanically anodized for at least 30 min. in the following bath maintained at 50 to 60 C. (120 to 140 F.). Ammonium Sulphate— 3.0% (4 oz. per gal.) Sodium dichromate— 3.0% (4 oz. per gal.) Ammonia (Sp.Gr. 0.880)—0.25% (⅓ fl. oz. per gal.) 6. The parts are finally washed in cold running water followed by a hot water rinse to facilitate drying.	1. This treatment is identical with the Dow No. 1 (Chrome-Pickle) treatment described previously up through the dip in the nitric acid-dichromate bath. After that the following procedure is carried out. 2. The parts are boiled for 30 min. in a 10 to 15% solution of potassium or sodium dichromate. 3. They are then rinsed thoroughly in cold running water followed by a hot rinse to facilitate drying.	1. After suitable cleaning and pickling (if necessary) either one of the two procedures utilizing the following solution may be used: Magnesium sulphate ($MgSO_4 \cdot 7H_2O$).....8.0 oz. Potassium dichromate ($K_2Cr_2O_7$).....5.3 oz. Water.....to make 1 gal. *A. For Small Scale or Occasional Use:* 2. The parts are immersed in the above bath for 30 to 60 min. at room temperature. 3. They are then rinsed in cold water and finally in hot water to facilitate drying. *B. For Production Use:* 2. The parts are immersed in the above bath for 10 to 20 min. at 150 to 160 F. 3. They are then rinsed in cold water and finally in hot water.	1. The parts to be treated are thoroughly cleaned by means of alkaline cleaning or vapor degreasing. 2. Oxide films may be removed prior to treatment by sand-blasting, pickling, wire brushing, etc. 3. The parts are then anodically treated for 15 to 30 min. at a current density of 10 to 20 amp. per sq. ft. in a bath containing 5 to 10% lithium hydroxide and 10% diethylene glycol. 4. The articles are then washed in cold water followed by a hot water rinse to facilitate drying.	1. The articles are cleaned and pickled. 2. Immersed for 5 min. in a 15% solution of hydrofluoric acid at room temp. 3. Thoroughly rinsed in cold water. 4. Anodically treated in the following bath: sodium dichromate 13.4 oz.; monosodium phosphate 2.67 oz.; water to make 1 gal. at 5 to 10 amp./ft.², 3 to 6 v., pH 4.2 to 4.8, temperature 122 F. time 45 min. 5. Finally the parts are thoroughly rinsed in cold water followed by a rinse in hot water.
Notes and Comments	1. The protection against salt water and the uniformity of the coating obtained are superior to those provided by the chrome-pickle treatment. However, the treatment is inferior to the Dow No. 7 treatment for salt water protection. 2. The paint adhesion property of this coating is superior to that of the chrome-pickle treatment on magnesium-manganese alloys. 3. This treatment effects only very slight dimensional changes on magnesium alloys and may be used on machined parts. 4. Brass, bronze, and steel inserts are not affected during this treatment, but aluminum is readily attacked during the hydrofluoric acid dip. 5. Note that the solution used in this treatment is the same as that used in the Dow No. 8 treatment. 6. The current density should not exceed 10 amp. per sq. ft. of anode area or a loosely held, powdery coating will result. 7. The color of the coating may be influenced by the time of treatment, condition of the bath, and alloy composition. Gray, non-uniform coatings are signs of improper cleaning before treatment or depletion of the solution. 8. The abrasion resistance of the coating is fairly good.	1. The increased corrosion resistance imparted to sand castings is not very great, but the increase in corrosion resistance of die castings is considerable. Specification AN-M12 says that an acid pickle or HF dip shall be given castings prior to application of Dow No. 10 treatment. Very corrosion resistant coatings can be obtained on sand castings. 2. A satisfactory sealing bath contains 1 lb. of technical sodium dichromate per gal. of water. 3. The pH of the sealing solution should be maintained at 4.0 to 4.4 by suitable additions of chromic acid. 4. The abrasion resistance of the coating is comparatively poor.	1. Dow Treatment No. 9 is more protective than this treatment and is superior for general use. However this treatment may be necessary where low electrical resistance is required. 2. The Dow Treatment No. 11 has been used for aircraft conduits and fittings. 3. Glass, aluminum, iron, or earthenware tanks may be used for containing the coating bath. 4. If a metal tank is used for containing the bath, the magnesium articles in the bath should not be allowed to touch the tank. The potential difference resulting from the contact between magnesium alloys and the metal of the tank may be sufficient to cause a spark to jump between the two, resulting in the ignition of the evolved hydrogen. 5. The bath for small scale use should be discarded when satisfactory coatings can no longer be obtained. 6. The bath for production use may may be controlled by maintaining the pH at 3.0 to 4.0 by small additions of H_2SO_4 when necessary as indicated by an inability to obtain uniform films after 20 min. of treatment. Water lost by evaporation should be replaced and the correct $K_2Cr_2O_7$ content maintained by analysis.	1. The bath temperature should be maintained at 160 to 195 F. 2. The coating produced is not particularly effective as a base for paint because of its alkaline nature. 3. The coating can be dyed by immersing the coated articles for a few minutes to ½ hr. in boiling aqueous solution of about 0.1 to 0.4% of a variety of water soluble organic dyes.	1. This treatment forms a coating which is an excellent paint base. 2. The corrosion resistant qualities of the coating are superior. 3. One disadvantage of the process is that its anodic throwing power is not too good. Portions of the anode closest to the cathode are more completely anodized than the recessed portions. 4. This treatment, which was developed by the government, is known as the Navy PT-13d process.

Fig. 5. Dichromate-treated vs. chrome-pickled magnesium alloy panels after 50 hrs. in salt spray.



Processes Developed Since 1940

Many treatments for magnesium and its alloys have been devised since 1940. In order to bring the reader up to date, all chemical surface treatments developed since 1940 are briefly summarized in this section:

Date	Patent No. or Treatment Designation	Inventors	Principal Reagents	Brief Description of Process	Remarks
May 23, 1940	German 692,311	Adolf Beck, Gustave Siebel, and Ed. Nachtigall	1—Alkali and ammonium salts of saturated and unsaturated fatty or hydroxy fatty acids with 8 or more carbon atoms or 2—of aromatic carboxylic acids with two carbon atoms.	Magnesium alloys are coated by heating in an aqueous solution of such organic compounds that form insoluble salts with magnesium. The solutions used may be those listed under "Principal Reagents." Additions of nitrates and sulfates will hasten the coating. Soluble silicates, chromates, and manganates will make the coating harder and more corrosion resistant.	Dyes can be added if a colored coating is desired.
June 11, 1940	U. S. 2,203,670	R. W. Buzzard	1 to 30% water soluble dichromate, 8 to 12% manganous sulfate.	Magnesium alloys are immersed for 5 min. to 1 hr. in an aqueous solution of 1 to 30% sodium or potassium dichromate and 8 to 12% manganous sulfate. The temperature of the bath is maintained at about the boiling point of the solution.	
June 17, 1940	British 522,382	Jean Frasch	Soluble silicates, aluminates, sodium, potassium, or lithium hydroxide.	The articles are anodically treated in a water solution of a soluble silicate, or aluminate and alkali hydroxide, maintained at room temperature. The pH of the solution is maintained at 8.5 to 12 by adjustment of the alkali content.	Another essentially magnesium hydroxide forming treatment. Not suitable as a paint base.
June 25, 1940	British 522,681	Magnesium Elektron, Ltd.	Alkali metal phosphates and silicates.	Corrosion of magnesium alloys by corrosive liquids is inhibited by adding small amounts of phosphates and silicates of alkali metals to the corrosive liquids.	The pH of the liquid should be maintained at about 8 to 10.
July 2, 1940	U. S. 2,206,028	R. W. Buzzard	Water soluble chromate and sulfate.	The articles are anodically treated at current densities up to 100 amps per sq. ft. in an acid solution of a water soluble chromate and a water soluble sulfate.	A suitable solution may be one containing 100 grams per liter of sodium dichromate and 5 grams per liter of sodium sulfate.
Aug. 2, 1940	British 524,290	Magnesium Elektron, Ltd.	Alkali metal or ammonium vanadates, molybdates, titanates, columbates, uranates, etc.	The articles are immersed in a solution of ammonium potassium, or sodium vanadate, molybdate, etc. for 5 to 30 min. The baths are maintained at 40 to 60 C. and the pH at 4 to 7.	
Aug. 20, 1940	British 525,033	Jean Frasch	Chromic acid.	The metal is electrolytically treated with an alternating current in a bath containing chromic acid. The pH of the bath is maintained below 2.	The coatings deposited are highly resistant to corrosion, but the throwing power of the solution is poor.
Aug. 22, 1940	German 696,601	Kurt Schwabe	Sodium hydroxide solution water or alkali soluble cellulose ether.	The articles are anodically treated in a solution of sodium hydroxide to which has been added a water or alkali soluble celullose ether.	Further protection may be obtained by varnishing or waxing the coating which is not a particularly suitable paint base.
Aug. 30, 1940	British 525,590	Louis Renault	Potassium permanganate, ammonium fluoride.	The metal is first chemically treated in an aqueous solution of potassium permanganate or electrolytically with alternating current in a soluble fluoride bath and then anodically treated in ammonium fluoride or a mixture of ammonium and an alkali metal fluoride.	The first treatment is supposed to produce a porous deposit and the second one to produce a film of MgF_2 in the pores.
Oct. 24, 1940	British 528,234	Magnesium Elektron, Ltd.	Neutral fluoride or fluosilicate plus water soluble compounds of titanium, tungsten, molybdenum, vanadium, beryllium, or zirconium.	The water soluble compounds listed under Principal Reagents are added to a saturated aqueous solution of a neutral fluoride, or fluosilicate. The articles are anodically treated in the bath at a current density of 2 amp per sq. dm.	The solubility of the fluo-salts should be at least 30% at 20 C. (68 F.). Citric, tartanic, or oxalic acid additions in small quantities improve the quality of the coating.
Dec. 10, 1940	U. S. 2,224,528	Hubert Sutton and L. F. Le Brocq	Water soluble dichromate, aluminum alum.	The metal is immersed with or without current in a solution of a soluble dichromate plus an alum such as an aluminum alum. The temperature is the temperature of the room.	Potassium permanganate is sometimes added in addition to the other reagents.
Jan. 14, 1941	U. S. 2,228,259	H. K. DeLong, and J. B. Reid	Aqueous solution of an alkali carbonate.	A corrosion resistant coating is formed by the action of an aqueous solution of an alkali carbonate under pressure at a temperature above its normal boiling point.	The coating produced acts as an excellent dye base and may be used to produce colored finishes.
Jan. 21, 1941	U. S. 2,229,236	Adolf Beck, Gustav Siebel, and Ed. Nachtigall	Potassium palmitate.	The articles are treated with an aqueous solution of a salt of an aliphatic carboxy acid containing at least 8 carbon atoms, e.g. potassium palmitate, at close to the boiling point of the solution.	The degree of corrosion resistance obtained is not very high.
Jan. 21, 1941	U. S. 2,229,252	J. Michel, and F. Henneberger	Alkali metal fluoride alcohol.	The articles are anodically treated at room temperature in an alcoholic solution of an alkali metal fluoride.	
Jan. 31, 1941	British 532,809	The Dow Chemical Co.	Alkali metal carbonate.	The articles are immersed in an aqueous solution of an alkali metal carbonate maintained at temperatures above 100 deg. and below 250 C. at increased pressure.	The coating acts as a satisfactory dye base but not as a satisfactory paint base.
Feb. 3, 1941	British 532,878	The Dow Chemical Co.	Carbonates or hydroxides of Ba, Li, Na, or K. Soluble dye.	The articles are immersed in a solution of a soluble base such as those noted under Principal Reagents, and a dye soluble in the solution under a pressure of 20 to 400 p.s.i. at a temperature between 110 and 250 C. (480 F.)	Colored protective hydroxide coatings may be formed in this manner. The coatings are relatively hard and abrasion resistant.
Feb. 21, 1941	British 533,841	Magnesium Elektron, Ltd.	Sodium potassium, or ammonium salts of saturated or unsaturated fatty acids, or hydroxy acids containing 8 or more C atoms, or carboxylic acids having 2 or more C rings.	The articles are immersed in solutions composed of reagents noted under Principal Reagents at the boiling point of the solution until a satisfactory coating forms.	The formation of the coating is accelerated by small additions of water soluble sulfates or nitrates.

Date	Patent No. or Treatment Designation	Inventors	Principal Reagents	Brief Description of Process	Remarks
Mar. 7, 1941	British 534,471	The Dow Chemical Co.	Soluble fluoride, sodium potassium, or ammonium salt of the oxygen acid of either Cr, Mo, P, Se, Ti, W, and V.	The articles are first immersed in a bath containing a soluble fluoride and then into a bath containing one of the oxygen acids listed under Principal Reagents.	
Mar. 27, 1941	British 535,067	Magnesium Elektron, Ltd.	Chromic acid, mineral acid, organic dye.	Die castings containing 4 to 15% Al are treated in an acid bath containing chromic acid ions and an organic dye which will not decompose in the solution.	The attempt here is to produce colored protective coatings.
April 18, 1941	British 535,695	The Dow Chemical Co.	Alkali metal or ammonium salts of oxygen acids of Cr, Mo, P, Se, Ti, W, or V. Arsenic sulfides.	The articles are immersed in solutions of salts of the oxygen acids noted and then in a solution of arsenic sulfide.	
May 29, 1941	German 707,722	Albert Block	Na, K or NH_4 salts of the oxygen acids of V, Mo, W, Cb, Ta, or U.	The articles are immersed in an aqueous solution of one of the reagents listed under column of "Principal Reagents".	The solution is maintained on the acid side at a pH of 4-7.
July 8, 1941	U. S. 2,248,062	R. W. Buzzard	Water soluble chromate or dichromate.	Anodic coatings are subjected to an immersion in an aqueous solution of a chromate or dichromate.	The solution is in reality a "sealing" solution.
July 8, 1941	U. S. 2,248,063	R. W. Buzzard	Water soluble chromate or dichromate and borate.	Same as above but borate is added to the bath.	
July 29, 1941	U. S. 2,250,472	H. K. DeLong	NaOH, Na_2CO_3, or LiOH and a water soluble dye.	The articles are immersed in an aqueous solution of NaOH, Na_2CO_3, or LiOH and a dye soluble in the solution under a pressure of 20 p.s.i. at a temperature above the normal boiling point of the solution.	The treatment produces colored corrosion resistant coatings.
July 29, 1941	U. S. 2,250,473	H. K. DeLong	NaOH or LiOH.	The articles are immersed in a 2 to 20% solution of NaOH or LiOH at a temperature of 150 to 250 and under a pressure corresponding to the vapor pressure of the solution at the operating temperature.	
Sept. 26, 1941	British 539,861	Magnal Products Ltd., F. A. Allen, Jack Morgan, and Magnesium Elektron, Ltd.	Caustic soda, steam, and free oxygen.	After a pretreatment in an aqueous solution of caustic soda, the articles are subjected to steam and free oxygen at normal atmospheric pressure for a period long enough to produce the desired thickness of coating.	The coating formed is essentially magnesium hydroxide. It is not suitable as a paint base.
Nov. 11, 1941	U. S. 2,261,960	R. W. Buzzard	Water soluble dichromate and phosphate, fluoride, borate.	The articles are anodically treated in an aqueous solution of a water soluble dichromate and phosphate and then again in an aqueous bath containing chromate, dichromate, fluoride, or borate.	The paint base qualities of the coating are satisfactory, but the solution throwing power is not too good.
Dec. 30, 1941	U. S. 2,268,331	Earl G. Crooks	Alkali metal borate and bicarbonate.	The articles are immersed in a hot aqueous solution of an alkali metal borate and a bicarbonate of an alkali metal or of ammonium.	The typical hydroxide coating containing borate and carbonate is formed.
Jan. 13, 1942	U. S. 2,269,435	R. W. Buzzard	Water soluble dichromate, nitric acid, magnesium fluoride.	The articles are first chrome-pickled and then immersed in a solution containing sodium dichromate and magnesium fluoride.	
Mar. 10, 1942	British 543,726	High Duty Alloys, Ltd., and Lawrence Whitby		The articles are electrolytically treated in an alkaline solution containing a high percentage of dissolved salts, at potentials above the sparking potential until a satisfactory coating is formed.	The sparking potential may be reached gradually or attained immediately.
Mar. 17, 1942	U. S. 2,276,286	R. W. Buzzard	Water soluble phosphate, borate, molybdate or fluoride, waxes, resins, dying oils or petroleum base oils.	Anodized articles are immersed in a hot solution of a phosphate, borate, molybdate or fluoride at a pH of about 4.5. They are then immersed in a liquid bath of a water proofing agent listed under "Principal Reagents", until the evolution of gas ceases.	A suitable anodic treatment is the Navy PT. treatment.
June 2, 1942	Canadian 405,154	W. S. Loose, and H. K. DeLong	Hydrofluoric acid sodium dichromate.	The articles are immersed in an aqueous solution of hydrofluoric acid (15 to 20% by wt.) and then in a solution of sodium dichromate maintained at a pH of 12-14.	
June 23, 1942	U. S. 2,287,049	Mike A. Miller	H_2SO_4 and phenol resorcinol, pyrogallol or gallic acid.	The articles are immersed in a 1 to 10% solution of H_2SO_4 containing about 0.5 to 15% of one of the reagents listed under "Principal Reagents".	
June 23, 1942	U. S. 2,287,050	Mike A. Miller	H_2SO_4 and oxalic, malic, citric, or tartaric acids.	The same as above except for the different addition reagents.	
June 30, 1942	U. S. 2,288,552	Gustav Siebel, and Ed. Nachtigall	Soluble dichromate and organic dye.	After heat treating at 320 deg. for a few hours, the articles are first chrome-pickled and then immersed in an aqueous solution of a dichromate and an organic dye.	A black matte coating is produced, particularly on die-castings.
July 7, 1942	U. S. 2,288,995	H. K. DeLong	Water soluble fluoride and a mineral acid.	The articles are immersed in an acidified solution of a water soluble fluoride.	The treatment is merely used to prepare the surface for painting.
Sept. 15, 1942	U. S. 2,295,842	J. D. Hanawalt, and C. E. Nelson	Alkali metal. Halides.	The articles are immersed for a few hours at 85 to 120 deg. in an aqueous solution of a chloride, bromide, or iodide.	The corrosion resistance of the coating is nil. However, the inventors claim only decorative effects on the more corrosion resistant magnesium alloys.
Sept. 15, 1942	U. S. 2,295,843	J. D. Hanawalt, and C. E. Nelson	Water.	The articles are immersed in water at 85 to 100 deg. at normal atmospheric pressure.	The hydroxide coating formed may be readily dyed.

Date	Patent No. or Treatment Designation	Inventors	Principal Reagents	Brief Description of Process	Remarks
Oct. 12, 1942	British 548,479	Yorkshire Dyeware and Chemical Co. Ltd., Bedford, Storey, and Kirkham	Phosphoric acid.	The articles are immersed in a phosphoric acid solution until a satisfactory deposit of Mg phosphate is formed. The article is then heated to dehydrate the coating.	
Dec. 12, 1942	U. S. 2,305,669	N. Budiloff, and W. Schnabel	Sodium aluminate and alkali metal phosphate, arsenate, or fluoride.	The articles are immersed in the aqueous aluminate bath containing Na_3PO_4 or NaF for example.	The coatings formed are fairly hard and abrasion resistant.
Feb. 9, 1943	U. S. 2,310,487	H. K. DeLong	Water soluble dye and ammonium acetate.	Coated articles which are to be dyed are immersed in a solution of a water soluble dye and ammonium acetate.	A typical dye which may be used is Neolan Bordeaux R.
Mar. 16, 1943	U. S. 2,313,753	W. S. Loose	Acid or neutral fluoride or fluosilicic or fluoboric acids and an arsenic compound.	The articles are immersed in the fluoride or fluobaths first and then in a bath containing an arsenic compound.	An arsenic salt or As_2O_3 solution increases the corrosion resistance of the initially deposited film.
Mar. 16, 1943	U. S. 2,313,753	W. S. Loose	Fluosilicic acid.	After immersion in a 15% fluosilicic acid bath at a temperature of about 40 deg. until a satisfactory coating is formed, the articles are anodically electrolyzed.	
Mar. 16, 1943	U. S. 2,313,755	W. S. Loose	Alkali metal or ammonium salt of the oxygen acids of Cr, Mo, P, Se, Ti, W, or V and an arsenic compound.	The articles are immersed in a salt of an oxygen acid listed under "Principal Reagents" and then in an aqueous solution of an arsenic compound.	
Mar. 23, 1943	U. S. 2,314,341	R. W. Buzzard	Water soluble chromate.	The articles are anodized in an alkaline solution of a water soluble chromate.	
June 15, 1943 Sept. 14, 1943	U. S. 2,321,948	O. L. Shawcross	Alkali metal chromate, aluminum nitrate, alumina.	The articles are immersed in an aqueous solution containing an alkali metal chromate (about 1 to 10%) and basic aluminum nitrate (10 to 60%) plus an excess of alumina.	The alumina forms a complex aluminate with the aluminum nitrate.
June 22, 1943	U. S. 2,322,205	H. K. DeLong	Sodium dichromate, calcium or magnesium fluoride.	The articles are anodically treated in an 8 to 10% solution of sodium dichromate containing about 0.005% of calcium of magnesium fluoride.	The coating produced is suitable as a paint base.
June 22, 1943	U. S. 2,322,208	W. S. Loose, and H. K. DeLong	Hydrofluoric acid, sodium dichromate or sodium dihydrogen phosphate.	The articles are immersed in a 15 to 30% solution of hydrofluoric acid for 5 min. and then in a solution of sodium dichromate or di-hydrogen phosphate.	Sodium salts of the oxygen acids of Mo, Se, Ti, W, or V may be used in the second immersion.
July 27, 1943	U. S. 2,325,304	C. J. Bushrod	Oleic or stearic acids.	In order to inhibit the corrosion of articles in contact with methyl alcohol, about 1% of oleic or stearic acid is added to the methyl alcohol.	Any resulting acidity may be neutralized with ammonia.
Oct. 5, 1943	U. S. 2,331,270	P. F. George	Zinc chromate calcium carbonate.	In order to protect containers, composed of magnesium alloys, from corrosion when in contact with gasoline and water, a mixture containing 90% zinc chromate and 10% of calcium carbonate, magnesium carbonate or magnesium oxide is added to the container.	
Oct. 19, 1943	U. S. 2,332,487	W. S. Loose	Hydrofluoric acid and NaOH.	The article is immersed in a solution of hydrofluoric acid and then, without rinsing off, the acid is plunged into a solution of sodium or calcium hydroxide.	
Nov. 30, 1943	U. S. 2,335,826	P. F. George	Alkali metal or ammonium zirconate.	Containers made of magnesium alloys in contact with water may be protected against corrosion by adding a small quantity of an alkali metal or ammonium zirconate.	

Plating on Magnesium

Some Difficulties Encountered:

1.—Strong electropositive nature of magnesium alloys.

2.—Refractory and insulating qualities of the magnesium oxide and hydroxide coating.

3.—The weak mechanical nature of the magnesium hydroxide film.

When a magnesium alloy is placed in a common heavy metal bath *e.g.* copper, nickel, etc., the magnesium surface dissolves and reduces the heavy metal ions present in the plating bath so that deposition of the heavy metal occurs. The deposit formed in this manner is soft, friable, weakly bonded and very porous. Continued exposure of magnesium to these baths causes continued corrosion to occur. The deposition of heavy metals by immersion occurs instantaneously so that even if the difficulties listed above (2 and 3) did not exist, adherent deposits could not be formed on magnesium by following ordinary good plating practice.

Attempts to minimize deposition, by immersion, by connecting the magnesium article to the cathode pole of the source of current before immersing in the plating bath, have been of no commercial value. All magnesium surfaces, after having been exposed to air, water, or most solutions, immediately become oxidized. The coating, thus formed, prevents to a marked degree; the formation of a continuous electrodeposit. The adhesion of these deposits is very poor mainly because of the poor adherence of the oxidized surface itself to the basis metal.

In the case of plating on aluminum, the situation is much different. The aluminum oxide coating formed on the aluminum surface is very adherent. After etching, this coating serves as an anchorage layer for the subsequent deposit. It must be remembered that initial deposition does not occur on the aluminum oxide layer but in the pores of the aluminum oxide and directly on the aluminum proper.

Applications:

As has been stated, in order to protect magnesium from corrosion by electrodeposition, it is necessary to completely envelope the surface with a pore-free coating. Up to the present time the formation of a coating substantially free from pores has met with only very moderate success. Triple plates consisting of nickel, cadmium and nickel deposits on die-castings with a total coating thickness of 0.001 to 0.0015 in., where the cadmium and final nickel deposit had been buffed to reduce porosity, have withstood 20 hr. in the salt spray before pitting began. It can be seen from this consideration that electroplated magnesium articles will be

Table IX.—Nickel Plating on Magnesium

Plating Bath	*Range for Good Deposits*
1—Nickel sulfate plus various amounts of a saturated solution of NH_4F containing hydrofluoric acid (no boron present).	From 15 to more than 60 grams per liter of fluorine, between 10 and 60 amp. per sq. ft. (bath was agitated).
2—Nickel content of bath varied between 0 to 25 grams per liter, the ratio of Ni:F was kept constant at 1:2 g. per l. (no boron added).	The allowable current density increases with increased nickel content. Baths should not contain more than 90 g. per l. of nickel sulfate (20.1 g. per l. Ni) otherwise, a nickel salt tends to precipitate out.
3—Nickel sulfate 60 g. per l. Boric Acid 29.6 g. per l. Fluorine content varied between 0-60 g. per l. The amount of boric acid is sufficient to form $Ni(BF_4)_2$ when enough fluorine is added. Fluorine was added as ammonium fluoride and hydrofluoric acid.	Fluorine concentration is critical. No deposition occurred when the concentration of fluorine was below that concentration necessary to form $Ni(BF_4)_2$. An excess of fluorine is required in order to permit a wider range of current density. The addition of more than 20 g. per l. of excess fluorine with respect to the nickel results in lesser adhesion of the nickel deposit.
4—Nickel sulfate 60 g. per l. Fluorine 40.8 g. per l. Boric acid varied between 0 to 50 g. per l.	Good deposits were obtained between 0-30 grams per liter of boric acid and a current density of between 5 and 45 amp. per sq. ft. Fluorine must be present in excess of the amount required to form nickel borofluoride. Harder deposits are formed at the higher current densities.
5—60 g. per liter of nickel sulfate. BF_4^- ion content varied between 0 to 80 g. per l. Excess fluorine present in the bath at all times varied between 1.7 to 6.2 g. per l.	Excess of BF_4^- results in improved deposits and markedly better adhesion. Good deposits, however, were obtained in baths containing less BF_4^- ions than are required to combine with the nickel. At 45 g. per l. of BF_4^- ion, the maximum current density range was reached. 10 to 65 amp. per sq. ft.
6—Nickel sulfate ..... 60 g. per l. Boric acid ..... 30 g. per l. Fluorine ..... 40 g. per l. pH varied between 5.0 to 6.6	At a pH of 6.0 to 6.4 hard, hydrogen pitted deposits are formed. At 5.4 to 5.8 soft deposits are obtained up to a cathode current density of 25 amp. per sq. ft. at 5.0 to 5.2 the nickel plate is soft over almost the whole range of acceptable deposits and there is very little hydrogen pitting. Best adhesion is obtained at this range of pH.

confined to indoor use. Nickel plated magnesium die castings will last indefinitely if exposed indoors only. They may be used satisfactorily for office equipment, house furnishings, interior decoration work, etc.

Other applications for plated magnesium include plating for tinning and soldering purposes and providing the surface with a hard finish to enable the magnesium to better resist impact and friction. It may even be possible to reduce the notch sensitivity qualities of magnesium castings if these areas were coated with a firmly adherent thick deposit.

Processes

One of the first mentions of plating on magnesium in the literature appears in a British Patent dated April 26, 1926 by A.M. and Wm. Clark. The process is partly mechanical, partly electrolytic and partly chemical in nature. The surface of the part to be plated is first cleaned of oil, dirt, grease, etc. by conventional methods. The cleaning operation is followed by a mechanical roughening operation which may include a fine grade sand blasting. The mechanical roughening operation is followed by immersing the magnesium part in a weak hydrofluoric acid which should not exceed a 1% solution.

The purpose of the hydrofluoric acid is twofold:

1.—To roughen the surface of the magnesium chemically.

2.—To produce locally, together with the constituents of the electrolytic bath compounds which control the hydrogen ion concentration of the electrolyte.

After the hydrofluoric acid dip the excess solution is allowed to drain from the treated part, then without washing, the part is immediately immersed and made the cathode in the plating bath. After plating, the magnesium article is thoroughly rinsed with water. Rinsing in boiling water for an hour is recommended if maximum corrosion resistance is desired. The inventors state that nickel, iron, cobalt, or cadmium may be deposited directly on the magnesium. Where a final coating of copper is desired it is preferable to plate the article first with nickel.

The plating bath, in all cases for the metals discussed above, includes boric acid, the proportion of boric acid in the bath being relatively high. The anodes should be composed, of course, of the metal being deposited. The authors know of nobody's having carried out the above process on a commercial basis. However, historically, this method is of considerable importance. The Loose method which will be described in detail below is definitely of commercial importance. Loose may have based his work on Clark and Clark's findings as there is a similarity between the two treatments.

Nickel Plating

The following process was presented at the Eighty-First General Meeting of the Electrochemical Society by W. S. Loose of the Dow Chemical Co. It is the most generally accepted method whereby magnesium may be successfully plated commercially. The method is essentially as follows:

(1) Polishing and buffing.

(2) Cleaning by solvent degreasing using trichloroethylene.

(3) Cathodic cleaning in a bath having the following composition and operating conditions:

Sodium carbonate—$Na_2CO_3.10H_2O$	56 grams per liter
Trisodium phosphate—$Na_3PO_4.12H_2O$	110 grams per liter
Sodium hydroxide—NaOH	28 grams per liter
Sodium metasilicate—Na_2SiO_3	56 grams per liter
Sodium lauryl sulfate	7 grams per liter
Time of cleaning	1 min.
Cathode current density	50 amp. per sq. ft.
Temperature	70 to 90 C. (155 to 195 F.)

(4) Washing with hot then cold water.

(5) Etching in a modified chrome-pickle bath having the following composition:

CrO_3	120 grams per liter
HNO_3 (Sp. Gr.1.42)	112 cc per liter
H_2SO_4 (Sp. Gr.1.84)	1 cc per liter

All reagents should be of C.P. quality. The solution is used at room temperature and the parts are immersed for 5 sec. Chromic acid may be used alone but the addition of nitric acid and sulfuric acid both, improve the adhesion. This particular etch is an important step in the process.

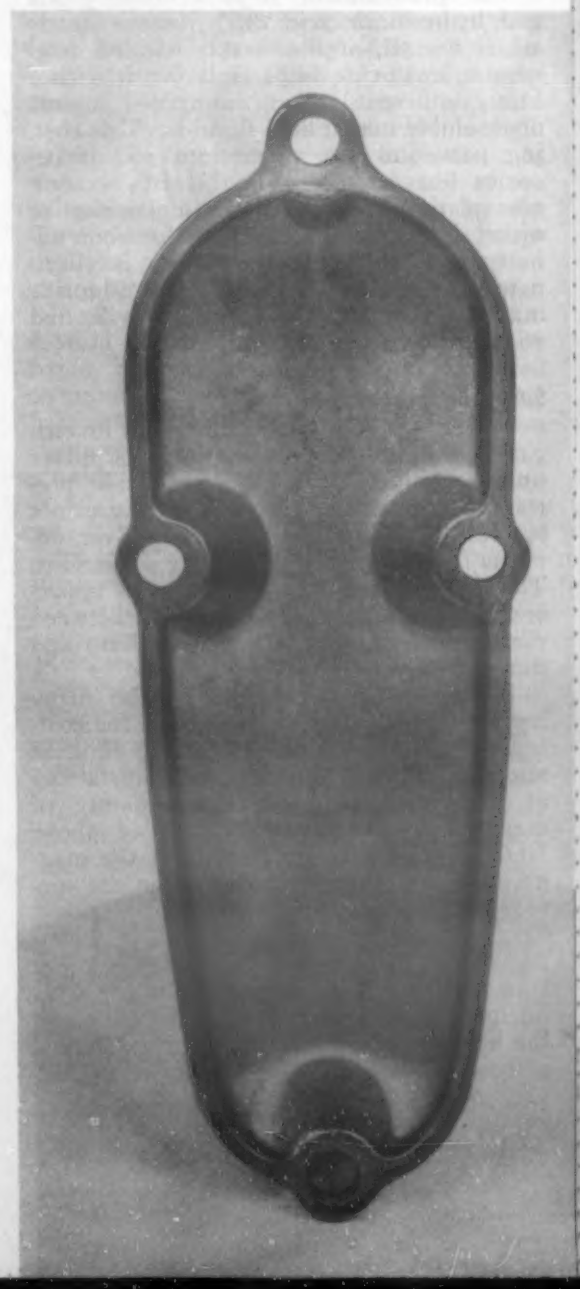
(6) Rinsing the chrome-pickled parts thoroughly with cold water.

(7) Acid dipping in the following bath:

Hydrofluoric acid—HF (52%)	200 cc per liter
Nitric acid—HNO_3 (C.P.)	10 cc per liter
Time of immersion	2 to 5 mins.
Temperature	70 to 90 F.

A certain amount of adhesion is secured on surfaces treated in the chrome-pickle bath which are not followed by the hydrofluoric acid dip. Adhesion, however, is insufficient for practical purposes, requires considerable etching of the surface and introduces chromium into the nickel plating bath. The chromium content of the plating bath gradually builds up and spoils the bath. Removal of the chromate film by dipping in hydrofluoric acid prevents the building up of chromium in the plating bath and insures much better adhesion with less severe etching in the chrome-pickle bath. The addition of nitric acid to the hydrofluoric acid, used to remove the chromate film yields exceptionally good adhesion between nickel and magnesium alloys.

Fig. 6. Nickel-plated magnesium die casting.



(8) Cold water rinsing.
(9) Nickel plating in the following bath under the following conditions:

$NiSO_4.6H_2O$ (nickel sulfate)	60 grams per liter
H_3BO_3 (boric acid)	35 grams per liter
NH_4F (ammonium fluoride)	65 grams per liter
Duponol ME (from E. I. duPont de Nemours)	
—Temperature	40 C.
Cathode current density	10-30 amp. per sq. ft.
pH	5.5

Hydrofluoric acid is used in place of some of the NH_4F in order to adjust the pH. The bath is made up by dissolving the ammonium fluoride and boric acid first. The pH is then reduced to about 5.9 with hydrofluoric acid. Nickel sulfate is then added and the pH adjusted to 5.5 with hydrofluoric acid.

For control purposes the analysis should be as follows:

Metallic nickel	13.4 grams per liter
Total boron	6.1 grams per liter
Total fluoride	50.0 grams per liter
Excess boron	1.2 grams per liter
Excess fluoride	6.0±2.0 grams per liter

The general observations of the plating study are tabulated below in Table IX. In all the baths listed, the plating was done in a polystyrene Hull Cell, total current 3 amps., temperature 45 C., plating time 45 mins., pH 5.3; with agitation.

While good deposits can be obtained in baths of the nickel fluorine type (See Figs. 6 and 7), they tend to decompose and the pH is difficult to control. A temperature of plating above 45 C. (113 F.) causes fairly rapid decomposition of the bath. Below 40 C. (104 F.) the deposits tend to become nodular and hard.

It will be seen from closely examining this procedure that the difficulties usually encountered in plating on magnesium, have been eliminated to a marked degree (see beginning of section "Plating on Magnesium").

The pretreatment steps (chrome-pickle and hydrofluoric acid dip) remove nearly all, if not all, of the weakly bonded magnesium hydroxide film; replacing it with a firmly adherent coating composed mainly of insoluble magnesium fluoride. This coating passivates the magnesium and it becomes less reactive. The $Ni(BF_4)_2$ complex plating bath retards the deposition of nickel by immersion so that the poor adherence of this type of coating is eliminated. It is believed that this borofluoride method of plating magnesium will find widespread use in the future.

Silver on Magnesium

Bowen and Gilbertson, in their investigation on the "Electrodeposition of Silver on Magnesium,"[19] tried the fluoride pretreatment described above, but were not successful in obtaining desirable silver deposits following their preplating operations. The authors state that the reason is apparently due to an action taking place between the fluoride deposit on the magnesium and the electrolyte.

It should be noted that of the many methods which have been devised for coating magnesium (oxide, chromate, fluoride, selenide, etc.) none had proven satisfactory as an undercoating for silver plating of magnesium. Baths with a pH of above 10.6 are unsatisfactory because of the magnesium hydroxide which forms on the surface and prevents the adherence of silver. The ordinary cyanide-carbonate silver plating bath used for silver deposition is not suitable for the electrodeposition of silver on magnesium. The deposits are flaky and the basis metal becomes badly pitted during plating.

Elimination of the carbonate from this bath tends to reduce pitting and to partially eliminate the reaction of the electrolyte with the magnesium, but does not produce satisfactory silver deposits. All of the magnesium used throughout the investigation was produced by electrothermic reduction, distilled, extruded and hot rolled. Highly polished magnesium specimens were used because it was found that highly polished specimens did not pit as readily or as severely as rough magnesium. The method finally adopted is outlined below:

(1) Cathodic cleaning in a bath of the following composition:

Sodium carbonate	56 g. per l.
Trisodium phosphate	110 g. per l.
Sodium hydroxide	28 g. per l.
Ammonium lauryl sulfate	2-8 g. per l.
Time	1-2 min.
Cathode current density	20 amps per dm^2
Temperature	60 to 90 C. (140 to 194 F.)

(2) Cold water rinsing
(3) Anodic treating in a trisodium phosphate duodecahydrate solution — 250 g. per l.

Temperature	60 to 80 C. (140 to 176 F.)
Cathode current density	30-40 amps. per dm^2
Time	3 to 6 min.

A gray film is formed on the surface of the magnesium which is adherent, smooth and stable.

(4) Cold water rinsing
(5) Copper striking in a bath of the following composition:

Copper cyanide	5 g. per l.
Potassium cyanide	100 g. per l.
Cathode current density	25 amps. per dm^2
Time—1 to 30 sec. depending on the condition of the metal surface or until the magnesium is covered with copper.	
Temperature	20 to 25 C. (68 to 77 F.)

(6) Cold water rinsing
(7) Plating in a bath of the following composition:

Silver cyanide	8.7 g. per l.
Potassium cyanide	11.2 g. per l.
Boric acid	10 to 30 g. per l.

Anode to cathode ratio should be 1:6 because larger anode areas shorten the life of the bath and produce a discolored plate.

Cathode current density	0.1 to 0.4 amps. per dm^2
Temperature	20 to 25 C. (68 to 77 F.)

The silver deposited on magnesium by this method is white, smooth, and hard. Plates exposed to a laboratory atmosphere for several months remain adherent and appear the same as when they are plated except for a normal amount of tarnishing. The silver coatings, however, are porous and do protect the magnesium surface from tarnishing. Silver deposits not more than 0.001 in. are adherent. Heavy silver deposits (1.6 mm. and over), however, are quite readily removed from the magnesium after plating.

There are several problems connected with silver plating on magnesium, which must be solved before this process is commercially feasible. First, before commercial application of this method, the procedure for polishing the magnesium must be changed. The specimens are prepared by rubbing on finer and finer emery and finally polishing on a cloth covered wheel for 6 hrs. with alumina and soap. This procedure would not be suitable for production plating. Investigations must be made on silver plating of common magnesium alloys rather than on pure magnesium alone.

Fig. 7. Nickel-plated magnesium die casting subsequently buffed.

Difficulties may be experienced when plating magnesium alloys which do not appear when pure magnesium is plated. Bowen and Gilbertson have, however, demonstrated a method for silver plating on magnesium, which is hardly more complicated than the ordinary silver plating of the common metals. The only additional step necessary is a 3- to 6-min. anodic treatment in the trisodium phosphate solution.

It is interesting to notice that of the three plating baths discussed above, all contained boric acid. It is also well to point out that two of these baths used hydrofluoric acid in their pretreatment processes. And that the necessity of pretreatment is well recognized. It is hoped that these investigations of pretreatment will help throw some light on the theories and hypotheses proposed for adhesion of electrodeposits in general.

Other methods for plating on magnesium have been attempted along different lines. Two of these processes will be briefly described in order to give the reader an insight into the unusual methods of attack that have been attempted.

British Patent 507,342—June 14, 1939

Articles are coated with a nonconductive lacquer or varnish, preferably of neutral reaction, on which a conductive layer *e. g.* silver, is then deposited by treatment with a reducible metal salt solution; the metallized surface is then electroplated, *e.g.* with copper from an acid bath. Nickel or chromium may be finally deposited. The article may be roughened before applying the lacquer. Aside from the fact that this procedure is lengthy and time consuming, it will find little application because of the many difficulties and technical problems inherent in the process.

The authors have attempted electroplating on magnesium in the above manner before we had knowledge that an investigation was being carried out elsewhere. To begin with, the surface of the magnesium should be chemically pretreated so that it will provide a good paint base for the varnish or lacquer, secondly the varnish or lacquer coating must of necessity be of very high protective value (possibly 3 or 4 coats will have to be applied) in order to withstand the action of an acid electroplating bath (plating on silver films is usually done from an acid copper bath for best results) and thirdly, the adhesion of silver, covered with electroplated metal, to a lacquer or varnish coating is very poor unless the lacquer or varnish coating is roughened by sandblasting or some other mechanical operation.

German Patent 688,485—Feb. 1, 1940,—B. Berghaus and W. Burkhardt

The surface of the article is first cleaned and freed of oxides, coated with a corrosion resistant surface, *e.g.* dichromate, fluoride, etc. and then a metallic intermediate layer is applied. The latter may be Cu, Ag, Zn, Cd., etc. and is applied by means of a sputtering electrode. The temperature of the object should be such as to cause the sputtered metal to alloy with it. The electrode vessel is best filled with nitrogen, argon or their mixture, plus a small amount of hydrogen. The final layer, preferably of a hard metal such as chromium or nickel is applied by electrolysis. One immediately obvious difficulty with this method is the sputtering, itself, which must be carried out at low pressures. There are many other difficulties which would entail going into the technical aspects of sputtering and therefore will not be discussed here. Suffice it to say that the application of electrodeposits in this manner would be extremely expensive and hardly practical at this time.

Of the various processes offered to the electroplater for plating on magnesium, only those which depend upon chemically treating the surface prior to plating are of any commercial importance. Prior to 1940 there were no processes which showed promising results. The fact that the plating of magnesium has now been shown to be commercially feasible opens a new market for magnesium alloys.

Painting Magnesium Alloys

Of all the known methods of protecting magnesium and its alloys against salt water corrosion, surface treatment followed by suitable painting has been by far the most successful. Since magnesium cannot be protected commercially by coating with more electropositive metals, the only remaining satisfactory method of protection is by the interposition of a continuous adherent film between the surface of the magnesium and the atmosphere to which the part is to be exposed. It is quite apparent that the coating immediately adjacent to the magnesium surface should, preferably, have an inhibiting action on the corrosion of the magnesium. In some cases it may be permissible to use a primer which does not have an inhibitive action but in these cases the primer must be inert so that at least there will be no accelerated corrosion.

A general feature of paint coatings is the ease with which the appearance of the coated article may be modified. Practically any color, surface texture or degree of gloss is obtained on magnesium alloys as well as other alloys. However, this article will be confined to the painting of magnesium and its alloys to prevent corrosion. The following discussion will be divided into five sections as follows: Adhesion; Chemical pretreatments; Primers; Finish coats; Paint schedules.

Adhesion

When paint is applied over untreated magnesium alloys and exposed to the atmosphere, peeling and blistering of the coating usually occurs.[20] There have been various theories proposed to explain this phenomenon. Perhaps the most plausible is that proposed by Whitmore[21] to explain paint failure on zinc, cadmium and magnesium. His data shows the extent of alkalinity developed on various metal surfaces immersed in water and salt solutions. The high alkalinity due to the rapid formation of magnesium hydroxide, on the surface of magnesium alloys is believed to be one of the main factors in causing poor adhesion of paint to these surfaces. The need for chemical treatment becomes immediately evident when it is realized that the formation of this oxide is so rapid that tests made immediately on freshly fractured or freshly machined surfaces show the presence of the oxide or hydroxide.

There are possibly other reasons why the adhesion of paint to magnesium alloys presents a special problem. However, providing the surface of the magnesium is made substantially inert and properly inhibiting by suitable chemical treatments and priming coats and providing high imperviousness to moisture is obtained by top coatings, there is no reason why a high degree of adhesion and protection should not be attained. It is necessary, of course, that good paint practice be followed throughout. The primary requirement is that the paint medium come into very close contact with the adherent surface film on the magnesium (produced by proper chemical pretreatment). If this is made possible the electrical forces residing in the atoms and molecules of the metal surface can readily interact with the electrical forces residing in the polar molecules of the finishing medium.

The need for cleanliness becomes apparent when it is realized that the distance over which these attractive forces can act efficiently is probably less than a few hundred Angstrom units from the surface of the adherent magnesium film. These short range forces are fundamental to the development of good adhesion. The effect of these electrical forces is increased many fold by mechanical or chemical roughening that increases the actual surface area of the metal many times and thus increases the total attractive forces between the paint and the surface of the metal. Mechanical or chemical roughening sometimes produces a keying effect of the paint coating to the metal itself.

Chemical Pretreatments

A satisfactory chemical pretreatment for magnesium is one which produces a continuous, adherent and inert film over the surface of the magnesium. It is desirable that this film contain ingredients which inhibit the corrosion of magnesium. It may be generally stated that in most cases chemical finishes which protect unpainted magnesium alloys against corrosion also provide a good paint base, (although treatments that provide maximum protection do not necessarily provide the best paint bases).

Of the treatments discussed previously the following have been shown to be quite satisfactory as paint bases:

1—Chrome-pickle treatment
2—Dow No. 7, 8, 9 and 10 treatments
3—Certain selenium treatments[22]
4—Anodic treatment (Navy Aeronautical Specification PT-13).

Most treatments involving chromates, dichromates or chromic acid improve the painting qualities of magnesium alloys. Of the five treatments listed, the chrome-pickle treatment or modifications of this treatment are the most widely used. This is probably due to the extreme ease with which the treatment can be applied, although there is much evidence to show the very valuable properties of the chrome-pickle film as a paint base. This process is explained in much detail above. Suffice it to say, here, that the matte-gray to yellow-red iridescent coatings show a pebbled etch under the microscope of depth and contour admirably suited for good anchorage as a paint base. Bright yellow or bright red iridescent coatings show a relatively smooth surface which provides little or no tooth for a paint film. The matte coatings are produced in fresh solutions and bright smooth deposits are produced in used solutions.

The Dow No. 7 treatment takes a longer time to apply than the chrome-pickle treatment. However, this treatment gives maximum protection against salt water corrosion and is recommended as a pretreatment whenever the part is to be exposed to severe marine conditions. The selenium treatments have not found widespread use probably because of the high cost of selenious acid. Anodic treatment (Navy Aeronautical Specification PT-13) has been developed by the government for naval aircraft use and has found widespread application.

Primers

In the paint system the primer is of the utmost importance. The thinner, vehicle and pigment must show little or no attack on the metal. The pigment should be at least inert, but preferably of such a material that will inhibit corrosion of the magnesium. The vehicle should be inert, have good adhesive qualities and have a high degree of imperviousness to moisture. As a check upon the possible influence of the primer, pigment tests[20] were run by the Dow chemical research staff, where strips of bare untreated metal were dipped in pastes of various pigments in distilled water. All of the leaded pigments with the exception of one, black iron oxide, antimony oxide, and some organic toners appeared to promote corrosion seriously. Lithopone, barytes, barium and calcium base titanium pigments caused slight corrosion; titanium-dioxide, zinc oxide, lampblack, aluminum-powder, basic lead chromate, red iron oxide, asbestine and most other extenders were inert. Zinc chromate alone was definitely inhibitive in its effect. It is logical that zinc chromate should be inhibitive as enough is soluble in water so that definite passivation of the magnesium should occur. Tests were also run on the influence of vehicles and resins on the properties of primers applied to magnesium alloys. The results are shown in Table X.

Fig. 8. Dipping a magnesium casting in an alkaline cleaner prior to chrome-pickle. Courtesy of Dow Chemical Co.

Table X.—Influence of Vehicles and Resins on the Properties of Primers Applied to Magnesium[20]

Primer	*Drying Time*	*Hardness*	*Adhesion*	*Water Resistance*[a]
Oil type	24 to 72	Poor	Good	Fair
Oleoresinous	12 to 24	Fair	Good	Fair
Alkyd resin	2 to 6	Good	Good	Fair
Modified alkyd resin	2 to 6	Good	Good	Fair
Modified phenol-formaldehyde resin	2 to 6	Good	Fair	Good
Vinyl resin	baked only	Good	Good	Good
Chlorinated Rubber	0.25 to 2	Good	Poor	Very good
Hydrocarbon resin				

[a] As determined by alternate immersion in 3% NaCl solution.

As mentioned above, the thinner used must not attack the magnesium. A suitable thinner is toluene or toluene substitute conforming to Army-Navy Aeronautical Specification An-T-8. If slower drying is desirable one fourth of toluene substitute may be replaced with xylene conforming to Army-Navy Aeronautical Specification An-R-X-876 or one fourth of the lacquer thinner may be replaced with Blush-Retarding Lacquer thinner conforming to Army-Navy Aeronautical Specification AN-TT-T258. In applying a primer which contains zinc chromate only as the pigment a hiding coat of full yellow color should be avoided. The coating should be a semi-transparent, greenish yellow.

Finish Coats

The requirements for a good top coat are: 1—Inertness; 2—Compatability with the primer; 3—Impermeability; 4—Durability and weather resistance.

The enamels which fit the above classification most closely are the synthetics, *e.g.* glycerol phthalate and phenol-formaldehyde types. The imperviousness of the top coating to moisture is substantially increased when aluminum pigments are used. These aluminum pigment particles themselves are coated with a layer of aluminum oxide and very frequently with a film of organic polishing compound. These coatings on the aluminum particles cause them to be substantially inert.

Owing to their method of manufacture the particles are lamellar in structure and are coated with an adherent organic film. When mixed with suitable liquids and applied to the surface these thin flakes float to the surface and overlap each other. This leafing action serves to lengthen the path through which the moisture must travel to get through the film as the aluminum pigment is quite impermeable. Aluminum pigments have the added ability to exclude ultra-violet light to a marked degree which aids in preventing corrosion of the magnesium. Each of these properties is fundamentally favorable to effective protection of the zinc chromate primer and magnesium beneath.

An idea of the added imperviousness obtained when aluminum is added as a pigment can be had from the following example: If 40 mg. of water would penetrate a 0.001-in. coating composed of a long oil varnish, the addition of aluminum pigment to the varnish would lessen the permeability to approximately 14 mg. penetration for the same thickness of coating. Other pigments besides aluminum have been used in industry mainly for the sake of a certain desired appearance. Carbon black is an example of a pigment widely used in top coatings on various magnesium castings.

Table XI shows the "moisture impedance" of an aluminum pigmented paint as compared with a light gray enamel.

Table XI.[23]—Moisture Impedance of Various Paints Used for Protection of Magnesium Alloys

Paint Coating	*No. of Finishing Coats*	*Moisture Impedance*
Zinc chromate primer (20 gals. phenolic resin varnish) plus aluminum paint[b] in same vehicle	2 3	38.7 52.8
P27[b] type zinc chromate primer plus aluminum paint in 20 gal. phenolic resin varnish	2 3	22.7 47.4
P27[b] zinc chromate primer plus light gray enamel made with 33 gal. phenolic resin varnish	2 3	18.4 20.2
Moisture impedance = area of film in sq. cm. x hrs. / mg. of moisture penetrated at 80 F., dry air one side 95% humidity air on other side		

[b] made with 2 lbs. of aluminum paste per gallon of vehicle. (This is the usual proportion.)

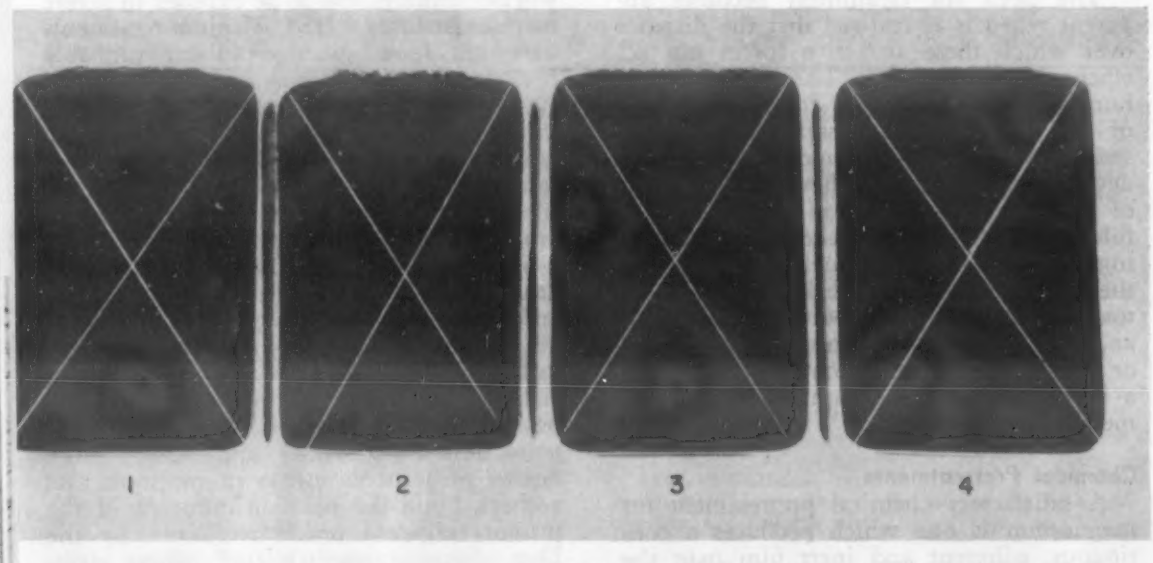


Fig. 9. Magnesium alloy corrosion test samples machined prior to accelerated corrosion test. Nos. 1 and 3 were primed with zinc chromate before painting. Nos. 2 and 4 were painted directly on the metal.

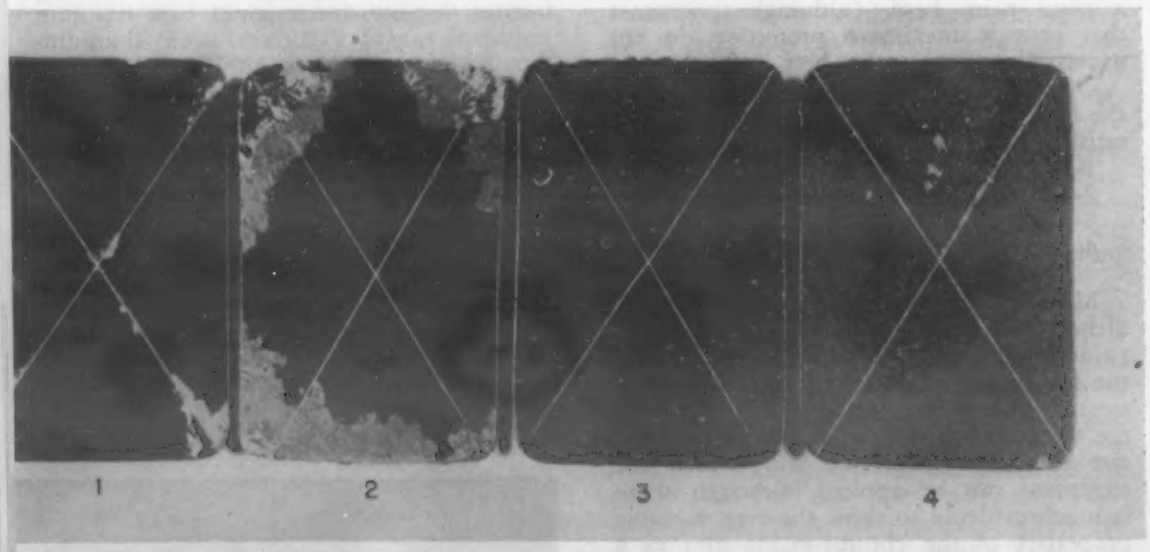


Fig. 10. Same samples as Fig. 9, after the corrosion test. Nos. 1 and 2 were salt-spray tested for 120 hrs. Samples 3 and 4 were subjected to constant humidity test for 120 hrs.

Paint Schedules

Throughout the other sections of this article the methods chemical treatment frequently suffices, applied by the manufacturers or the customer after fabrication as may be advisable. Certain or some baking paint systems have shown good adhesion to bare metal and are particularly adapted to the finishing of large quantities of die-castings for indoor services.

Magnesium properly painted will withstand corrosion extremely well for most applications. (See Figs. 9 and 10.)

Table XII.[24]—Recommended Chemical Treatment and Painting of Magnesium Alloys (Dowmetal)

Type of Part	*Service Condition*	*Chemical Treatment after Fabrication*	*Primer (one coat)*	*Finish*
Sand Castings	Indoor	Chrome pickle	Air dry or baking zinc chromate primers	One or more coats of oil base, synthetic or lacquer enamel
		none	Suitable zinc yellow primer meeting AN-TT-P-656a	
	Outdoor	Chrome pickle	Air dry or baking zinc chromate primers	2 or more coats of glycerol phthalate or phenolic resin enamel or varnish[2]
		none	Suitable zinc yellow primer meeting AN-TT-P-656a	
	Marine atmosphere	Dow No. 7 or 8	Zinc chromate	3 or more coats of glycerol phthalate or phenolic resin enamel or varnish. Aluminum pigment preferred[2]
Die Castings	Indoor	Chrome pickle	Air dry or baking zinc chromate primers	One or more coats of oil base, synthetic or lacquer enamel
		none	Suitable zinc yellow primer meeting AN-TT-P-656a	
	Outdoor	Chrome pickle	Air dry or baking zinc chromate primers	2 or more coats of glycerol phthalate or phenolic resin enamel or varnish[2]
		none	Suitable zinc yellow primer meeting AN-TT-P-656a	
	Marine atmosphere	Dow No. 7 or 8	Zinc chromate[1]	3 or more coats of glycerol phthalate or phenolic resin enamel or varnish. Aluminum pigment preferred[2]
Sheet, Extruded Shapes, Forgings	Indoor	Chrome pickle	Air dry or baking zinc chromate primers	One or more coats of oil base, synthetic or lacquer enamel
		none	Suitable zinc yellow primer meeting AN-TT-P-656a	
	Outdoor	Chrome pickle	Air dry or baking zinc chromate primers	2 or more coats of glycerol phthalate or phenolic resin enamel or varnish[2]
		none	Suitable zinc yellow primer meeting AN-TT-P-656a	
	Marine atmosphere	Dow No. 7 or 8	Zinc chromate[1]	3 or more coats of glycerol phthalate or phenolic resin enamel or varnish. Aluminum pigment preferred[2]

Effects of Composition on Corrosion

In the last few years many investigations have been made to determine the effect of various impurities and alloying constituents on the rate of corrosion of magnesium. The authors will not attempt to present all the work done in this discussion. However, an understanding of the corrosion of magnesium may be had only if the tremendous effects, caused by other metals incorporated in the magnesium, are brought to light.

Impurities in Magnesium

One of the most important investigations on the effects of impurities on the corrosion rate of magnesium was made by J. D. Hanawalt, C. E. Nelson and J. A. Peloubet of the Dow Chemical Co.[25] In this investigation, more than 5000 alloy specimens were observed and more than 50,000 quantitative analyses were made. The existence of certain tolerance limits were experimentally determined. The presence of impurities beyond these tolerance limits causes a tremendous increase in corrosion rates.

High purity magnesium was prepared by special vaporization techniques since it was found that the ordinary technique yielded magnesium non-uniform in iron content. A typical analysis of pure magnesium obtained in this manner is shown in Table XIII.

A sample of the high purity magnesium was submitted to an alternate immersion test in 3% sodium chloride solution. The cycle was ½ min. immersion followed by a 2-min. drying period. After one year there was substantially no loss in weight of the magnesium. Commercially pure magnesium submitted to the same test would be heavily corroded in a day or two.

A comparison of the corrosion rates of commercially pure magnesium and high purity is shown as follows:

Commercially pure....5 to 100 mg. per sq. cm. per day
High purity....0.15 to 0.05 mg. per sq. cm. per day

If we prepared specimens from the above two grades of magnesium so that the surface area is one square centimeter and the weight one gram, and if we assume that the average commercially pure magnesium

Table XIII.—Analysis of Pure Magnesium

Element	*% of Element*	*Element*	*% of Element*
Iron	<0.001	Sodium	0.002
Nickel	<0.0001	Manganese	<0.0005
Copper	<0.0001	Lead	<0.01
Aluminum	<0.001	Silicon	<0.001
Calcium	<0.001		

A typical analysis of commercially pure magnesium is shown in Table XIV.

Table XIV.—Analysis of Commercially Pure Magnesium

Element	*% of Element*	*Element*	*% of Element*
Iron	0.030	Aluminum	0.01
Nickel	<0.0005	Manganese	0.002
Copper	<0.005	Lead	0.001
Silicon	0.004	Sodium	0.005

corrodes at a rate of 50 mg. per sq. cm. per day and high purity at 0.15 mg. per sq. cm. per day, a simple calculation will show that after one year, the high purity magnesium specimen would have lost 0.06 grams in weight while the commercially pure specimen would have entirely disintegrated in 20 days. All the alloying elements added were obtained of suitable purity or purified by special techniques before the additions were made.

After submitting the specimens to the corrosive liquid, samples of the area to be studied were obtained by drilling with a small drill the diameter of which was less than the width of the area to be measured. Many of these corroded areas showed an iron content of as high as 0.05%; non-corroded areas contained less than 0.002%. In some cases there was no difference between the percent of iron in the corroded areas as compared with the non-corroded areas. However, later tests indicated the reason was probably due to the fact that most of the iron left the corroded area either by solution or was mechanically removed as the magnesium surrounding the iron was dissolved.

Another set of specimens was exposed to the corrosive liquid only until corrosion started. All samples taken from these specimens showed a greater percentage of iron in the corroded areas than in the non-corroded areas. The final group was studied by placing a drop of 3% sodium chloride solution on the specimen. The source of attack was observed and noted and the area was then immediately washed and dried and samples taken. The per cent of iron at this "source of attack area" was 0.05% and 0.001% at the non-corroded areas.

Attempts were made to analyze for nickel and chromium in locally corroding areas but these elements were not detectable by spectrographic or microchemical methods.

Approximate "tolerance limits" (the maximum amount of an element that may be present without affecting the characteristic corrosion rate of the alloy) for some metals are shown in Table XV. The following compounds or elements had no significant effect on the corrosion of pure magnesium: CaC_2, NH_4Cl, NH_4BF_4, S, Mg_3N_2, MgO, $MgOCl_2$, C, He, N_2, CS_2, C_2H_2, CO, CO_2, H_2, H_2S, HCl, Cl_2, CH_4, SO_2, O_2 natural gas and air.

Table XV.—Tolerance Limit of Some Elements

Metal	*Approximate Tolerance Limit %*	*Approx. Rate of Corrosion at Tolerance Limit, mg. per sq. cm. per day*
Iron	0.017	—
Nickel	0.025	Greater than 15
Cobalt	0.001	—
Copper	0.2 to 0.3	Greater than 15
Silver	a	12
Calcium	a	6
Zinc	a	3
Cadmium	a	less than 1
Lead	a	less than 0.5
Tin	a	less than 0.5
Aluminum	a	less than 0.5
Sodium	a	less than 0.5
Manganese	a	less than 0.5

NOTE:

[a] No sharp "tolerance limit"; values given under "Approximate" Rate of Corrosion etc. are at 5% concentration.

In the past various investigations have been conducted in order to determine the effect of various alloying constituents on the corrosion rate of magnesium. However, the effects of impurities upon the corrosion rate of the metal were not taken into account, and it may well be that the results attributed to various alloying constituents actually were caused by impurities.

Alloy Additions

A large number of additions to magnesium have been proposed [26, 27, 28, 29, 30] in order to increase its corrosion resistance. Silver, copper and nickel can, in general, not be used as their solubility in magnesium is only slight and an excess of undissolved metal remains which leads to galvanic action and corrosion. An addition of lead (0.5 to 22%) and of cadmium (1 to 10%) to magnesium alloys, with subsequent aging at 175 C. (365 F.) is said to produce high corrosion resistance. The same claim is made for the addition of 0.05% of antimony or bismuth to aluminum-magnesium and zinc-magnesium alloys.

An extraordinary increase in corrosion resistance is claimed for the addition of 0.005 to 0.5% addition of beryllium to magnesium (0.5% is the maximum solubility of beryllium in magnesium). The addition of beryllium favors a coarser grain structure. This can be counteracted by the addition of titanium or zirconium, the latter in amounts of 0.005 to 0.5%. The elements of the alkaline earth group also decrease the corrosion rate of magnesium. For example, the addition of 1% Ca to magnesium prevents magnesium from decomposing water vapor, which explains its resistance in humid air. Magnesium with 3% Li shows a considerable increase in mechanical strength and in corrosion resistance. British Patent 489,320 proposes magnesium alloys with 1 to 5% sodium or potassium.

The addition of chromium to magnesium alloys containing aluminum is as effective in reducing the rate of corrosion in 0.1 N hydrochloric acid as is the addition of manganese but in magnesium alloys containing both aluminum and manganese, chromium has no effect. The addition of cadmium even without the lead addition increases the stability of magnesium toward the atmosphere and fresh water.

In a study by the Japanese[29] for various binary alloys containing up to 8% each of the certain elements, the effect of added metals on the corrosion of magnesium is related to the position in the periodic table; metals belonging to the same series of the same groups gave a similar effect on the corrosion of magnesium in salt solutions. The metals studied are: Tin, bismuth, tellurium, cadmium, lead, zinc, antimony, aluminum, calcium, silver, copper, manganese, silicon, nickel and cobalt. Specimens were subjected to the action of distilled water, 0.1 normal sodium chloride solution or sea water, by means of dipping, spraying or intermittent testing.

A further investigation on cast ternary alloys containing zinc, cadmium, lead, tin, aluminum were studied. Fifteen series of alloys were prepared by systematic addition of two elements to magnesium. The amount of addition was from 1 to 8% except for antimony (0.3 to 3%). Results show that the following magnesium alloys have comparatively high resistance against corrosion:

Zinc 1 to 3% and tin 2 to 8%.
Zinc 3 to 6% and cadmium 1 to 6% (Zinc plus cadmium less than 10%).
Tin more than 3% and cadmium 1 to 3%.
Tin more than 4% and lead 1 to 6%.
Zinc 1 to 6% and antimony 0.3 to 0.6%.
Tin 2 to 3% and antimony less than 0.3%.

The corrosion inhibitive effect of manganese additions to Mg-Al alloys is fairly well known. A method of forming the manganese in the bath by addition of manganese chloride to the salt layer is described in German Patent 542,054 as early as 1926. The metal is melted under a salt layer containing 10 to 25% of CaF_2, then treated with about 0.5% Ca. The melt is stirred until the metal contains not more than 0.1% Ca. Manganese chloride is added to the salt layer in proportions to give 0.4% Mn.

In U. S. Patent 1,975,778, 1943, a method of coating a sheet or slab of magnesium with an alloy containing magnesium together with small amounts of mercury, tellurium or lead is described. It is claimed to improve the corrosion resistance of the magnesium base. As the time of aging magnesium-aluminum alloys is increased, the corrosion resistance is also increased. Manganese is often added to magnesium alloys to increase their corrosion resistance. It has been stated that the protective coating is substantially manganous hydroxide.

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METALS and ALLOYS

Engineering File Facts

NUMBER 72
February, 1945

MATERIALS AND DESIGN
Engineering Steels

Specifying Steels by Hardenability

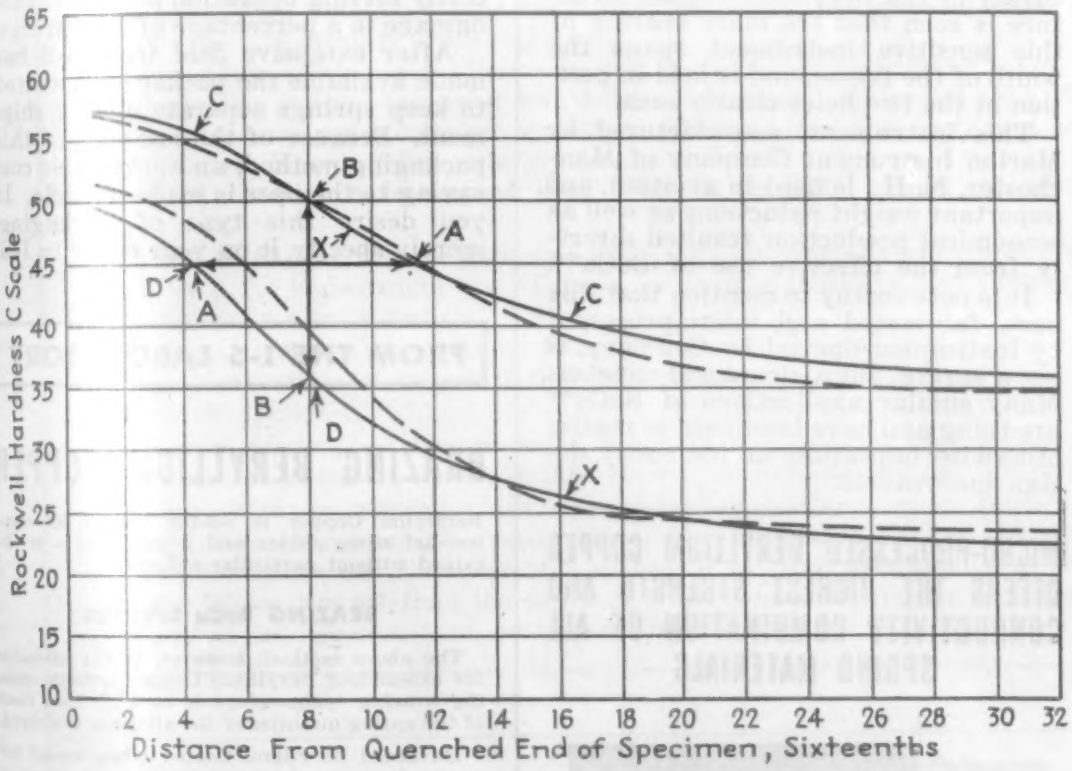
Use of the property of hardenability in specifying steels has come into favor within the past few years as closely related to the actual service requirements of the metal. To simplify the use of hardenability test results for specification purposes, a joint committee of the Society of Automotive Engineers and the American Iron and Steel Institute has prepared a tentative method.

The hardenability curve, in which hardness is plotted against distance from the quenched end of a standard size test bar, indicates the depth to which the steel may be expected to harden when quenched in heat treating. Such curves have been prepared from test data for many of the standard steels.

Because most engineers and metallurgists have been familiar with the heat treating characteristics of the older types of carbon and alloy steels, hardenability curves have been prepared chiefly for the newer N.E. steels.

In the case of the older steels, of standardized composition, the metallurgist through long experience had related the chemical composition to heat treating properties. The need for data giving heat treat characteristics of the new steels directly caused these compositions to be the subject of considerable experimenting with end-quench hardenability.

Results of these tests have been summarized for many compositions in a booklet, "Tentative Hardenability Bands," prepared by the joint committee.



When ordering steels according to hardenability, the full length of the curve should not be specified; instead, specific points on the curve are selected. It is recommended that two points be used to designate the desired hardenability for specification purposes.

The points may be chosen in any one of the following ways:

(1) As the minimum and maximum distances at which any desired hardness value occurs. These distances are indicated in the chart as the points A-A.

(2) As the minimum and maximum hardness values at any desired distance. Values indicated in the example as points B-B.

(3) As two maximum hardness values at two desired distances. The points C-C illustrate this method.

(4) By two minimum hardness values at two desired distances. For this method, the points D-D indicate the values chosen.

(5) By any point on the minimum hardenability curve and any point on the maximum curve. These points might be indicated by X-X in the diagram.

Because curves for individual heats may vary somewhat, deviations (shown dotted) from the specified maximum or minimum curve (shown solid) of not more than 2 points Rockwell C are considered permissible.

When considered desirable the maximum and minimum limits at the $^1/_{16}$ in. point may be included in addition to the two points selected as above.

The steel producer should show on shipping papers or by some other means heat hardenability at the reference points specified, or hardness values at the following distances from the quenched end of the specimen: $^1/_{16}$ in., $^1/_8$ in., $^1/_4$ in., $^1/_2$ in., $^3/_4$ in., 1 in., $1^1/_4$ in., $1^1/_2$ in., $1^3/_4$ in., and 2 in. Hardness values below Rockwell 20 C should not be recorded.

Hardenability should be determined in accordance with the standard 1-in. end-quench hardenability test, using a cast test bar, or a sufficient number of forged test bars to insure that the material meets the specifications. Forged test bars should represent the full cross-section of the product.

Steels specified by hardenability are indicated as H-steels, the H-designation preceding the S.A.E. classification number for the steel.

Standard blank forms for recording hardenability tests are prepared and distributed by the American Society for Testing Materials and by the Society of Automotive Engineers. The type offered by the former society is the more widely used, and is shown in the accompanying illustration.

Prepared from the report of a joint committee of the Society of Automotive Engineers and the American Iron and Steel Institute.

The I-S SPRINGBOARD

VOL. 2 NO. 1

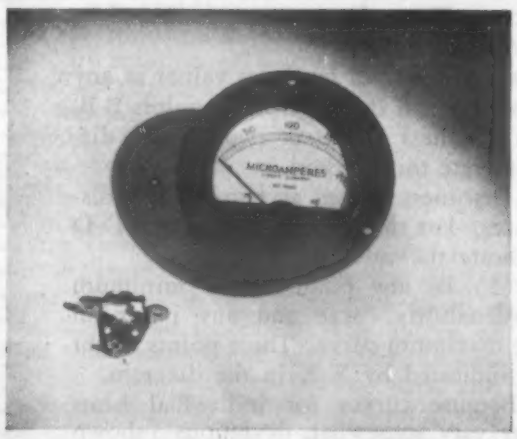
Published by INSTRUMENT SPECIALTIES CO., INC.

224 BERGEN BOULEVARD — LITTLE FALLS, NEW JERSEY

FILEWORTHY FACTS ABOUT MICRO-PROCESSED BERYLLIUM COPPER

INSTRUMENT FRAME FORMED FROM BeCu^{mp} ELIMINATES DIE CASTING MACHINING COSTS

Marion Instrument Company utilizes ability to obtain maximum use of properties of Beryllium Copper



The instrument frame illustrated here is a typical example of the profitable use of micro-processed Beryllium Copper to obtain lower production costs, lighter weight, and close tolerances.

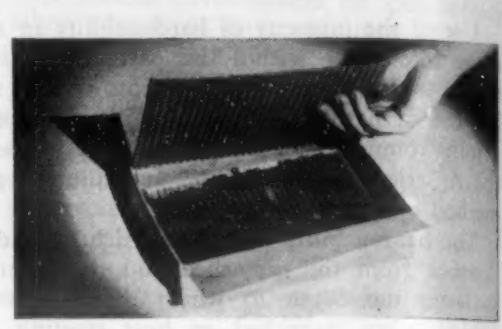
Beryllium Copper was indicated initially because of its non-magnetic properties and its ability to be formed in the annealed or soft state to obtain the intricate shape required. Desired high strength and stability is obtained by proper hardening heat treatment after forming — an inherent characteristic of micro-processing by Instrument Specialties Company.

This frame, fabricated from BeCu^{mp}, replaces a die casting which required thicker sections of greater weight to obtain equal strength. Tolerances obtained in the BeCu^{mp} part are equal in all respects to the die casting, and many machining operations are eliminated since the piece is formed from strip and requires no further work after hardening. The rigidity and accuracy of the Beryllium Copper structure is such that the main bearing of this sensitive instrument spans the width of the frame, and is held in position in the two holes clearly seen.

This instrument, manufactured by Marion Instrument Company of Manchester, N. H., is used in aviation, and important weight reductions as well as economical production resulted directly from the effective use of BeCu^{mp}.

It is noteworthy to mention that this part, fabricated and micro-processed by Instrument Specialties Company, is not a spring, but a structural member. Many similar applications of BeCu^{mp} are being and have been used to realize otherwise impossible or too costly design innovations.

NO-TANGLE PACKING REDUCES BRUSH SPRING ASSEMBLY COSTS



Because of the open pitch design, brush springs for small motors have always been subject to tangling in shipment. This usually results in a costly sorting operation and inevitable damage to a percentage of the springs.

After extensive field tests, I-S has made available the package illustrated to keep springs separate during shipment. Because of the low cost of this packaging method, an appreciable cost saving to the user is made possible. If you desire this type of packaging, merely specify it on your order to I-S.

WHAT MICRO-PROCESSING ADDS TO THE INHERENT PROPERTIES OF BERYLLIUM COPPER

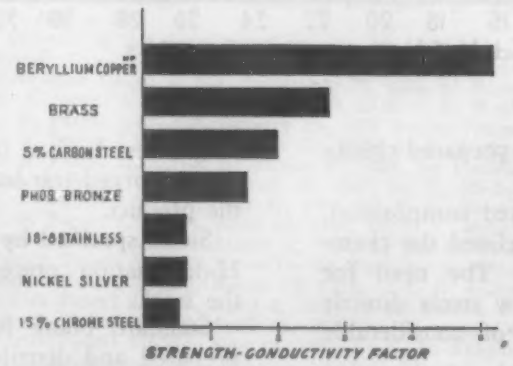
Beryllium Copper is a non-magnetic alloy, with the corrosion resistance of copper and the ability to be hardened by heat treatment. These properties are inherent with the alloy and are available to all users. Of chief value to the spring user, however, are those properties developed by micro-processing: high electrical conductivity, high stability, freedom from drift, endurance strength and close dimensional control in the finished spring.

These properties will not all reach their maximum at the same time at standardized temperature, and the temperature itself has a marked effect on the final properties obtained. Instrument Specialties Company maintains a complete engineering department and laboratory who will be glad to assist you in deriving maximum benefit from micro-processing applied to any individual problem or requirement.

LITERATURE

A few reprints are still available of the technical article "Making Beryllium Copper Behave," by R. W. Carson. This article included the first disclosure regarding heat treat forming to obtain predictably closer tolerances. A copy will be sent upon request.

MICRO-PROCESSED BERYLLIUM COPPER OFFERS THE HIGHEST STRENGTH AND CONDUCTIVITY COMBINATION OF ALL SPRING MATERIALS



Beryllium Copper is the only high strength spring material which also has good electrical conductivity. The steels have low conductivity although the spring strength is high, while the alloys offering better electrical conductivity are much weaker spring materials when compared with BeCu. Micro-processing offers the highest possible electrical conductivity with high strength.

FROM THE I-S LABORATORY

BRAZING BERYLLIUM COPPER

Beryllium Copper is readily brazed by commercial silver solder and a good union is obtained without particular difficulty.

BRAZING BeCu SPRINGS

The above method, however, is not advisable for assembling Beryllium Copper springs, since the brazing temperature is so high that most of the spring qualities of the alloy are destroyed.

Hardened Beryllium Copper when heated for even a few seconds at temperatures in excess of 800°F rapidly loses its hardness, thus making it impracticable to braze a hardened BeCu spring.

When Beryllium Copper is heated prior to hardening it should be done in the range of 1425° to 1475°F and quenched rapidly in water. Only by this means can the maximum amount of Beryllium be made available for hardening. Therefore, a BeCu part can be hardened to fair spring properties after brazing by using a brazing alloy which melts at the top of the annealing temperature range. But, to allow the part to be water-quenched, the brazing alloy must solidify before the lower end of the annealing temperature is reached.

Beryllium Copper may also be brazed by diffusing the brazing alloy within the BeCu, and subsequently solution heat treating and hardening. The resultant properties are comparable with those usually obtained when annealed BeCu is hardened.

These special techniques require extremely accurate control for successful results, and often involve the solution of allied problems which render them difficult to apply, and are not usually attempted unless no other ready means of assembly is feasible.

METALS and ALLOYS

Engineering File Facts

NUMBER 73
February, 1945

METHODS AND PROCESSES
Casting Repairs

Gray Iron Casting Repairs

To facilitate legitimate production by presenting approved repair practices for new automotive gray iron castings, the War Engineering Board of the Society of Automotive Engineers has prepared a bulletin outlining these practices. The bulletin is designed to indicate shop procedure for repair of such castings for the Armed Services, showing practices that are approved as satisfactory from a quality viewpoint, and mentioning practices that are unsatisfactory.

It is expected that the bulletin will provide a means for improvement of casting quality by discussion of kinds of defects existing, and of means for repairing them. Misunderstandings as to quality, standards of castings can be avoided between foundries, fabricators, and the armed services procuring the castings as finished products. The bulletin has been prepared at the request of the United States Army Ordnance Department.

Methods given in this bulletin are here summarized:—

Gas and Arc Welding

Extent—Flaw must be opened up to determine nature and extent of defect. Type of defect is not important except as it governs extent of repair to be made.

Preparation—Defect and adjacent areas must be thoroughly cleaned before welding is started. Flame gouging after preheating is best. Inspection with kerosene or mineral spirits and chalk, fluorescent oil, acid etching, or magnetic particles may assure complete removal of defect. Chipping, if used, must be done carefully to avoid hiding the defect. Rough chipping followed by grinding is preferable.

When cracks are to be repaired, small holes may be drilled beyond ends of the crack, and area ground out from hole to hole.

Preheat—Casting must be preheated slowly and uniformly to between 900 and 1100 F. for plain iron, or 1050 and 1250 F. for high-strength iron. Casting and furnace should be heated from not over 350 F., or 600 to 800 F. for large castings in a batch furnace.

Welding—Welding time should be held to a minimum, and started immediately after removal of castings from furnace. Temperature of casting should not be allowed to drop below 700 F. Under some circumstances auxiliary heat may be applied.

Rod or Electrode—Deposited metal should have a structure and hardness comparable to parent metal. Flux-coated cast iron electrodes should be used for arc welding, and similar rods for some torch welding.

Flux—With gas welding, a flux must be used to provide adequate flotation, fluidity, or puddling.

Post Heat—Post heating for stress relief should be done at 1000 to 1100 F. for plain iron, and at a temperature at least 50 F. below the critical for high strength irons. Very slow cooling to 700 F., and preferably much lower, is necessary before removal from the furnace. When furnace cooling is not possible, castings should be buried in powdered silocel, asbestos, lime, sand, charcoal, mica, crushed slag, etc.

Nickel Welding (Cold Welding)

For bore welding

Extent—Flaw must be opened up to determine its extent. No leaky bores will be nickel welded. (If cavity after cleaning exceeds 3/16 in. diam. in the ring travel, or 5/16 in. diam. outside the ring travel, or extends through more than one-half the machined thickness of the well involved, it shall be considered unrepairable.)

Preparation—Cavity after removal of flaw shall be absolutely clean. This is usually best done with a right angle drill, rotary file, etc.

Preheat—No preheat is used.

Welding—Welding transformer should provide low voltage with high heat (6 to 8 volts, and about 350 amps.) so that nickel is melted and scratched off the wire while in a plastic state. No continuous arc is held, as this would create a hard zone.

Rod or Electrode—Electrode is a bare wire, 94% Ni, not greater than 5/32 in. in diam.

Post Heat—No post heating is necessary.

Dressing—After completing the weld, it should be smoothed off with a small grinding wheel, and bore rehoned.

(Continued on page 443)

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NUMBER 73 (Continued) GRAY IRON CASTING REPAIRS

General Nickel Welding

Extent—This method is intended for repair of small defects in non-critical areas of machined castings, where subsequent machining or tapping is necessary.

Preparation—Flaw must be thoroughly cleaned by chipping, grinding, or machining.

Preheat—No preheat is used.

Welding—A standard arc welding machine is used. Amperage is held as low as is consistent with sound deposits. Heat in the casting should be held to a minimum. When using the intermittent welding technique, high amperages are used, causing an intermittent arc, and so lessening the tendency toward excessive heat accumulation and hard areas.

Rod or Electrode—Electrode is a coated commercially pure nickel or Monel metal rod, not exceeding 5/32 in. in diam.

Post Heat—No post heating is necessary.

Dressing—After the weld is completed it should be dressed with a small grinding wheel, or machined.

Special Repair Conditions

(A) *Gas Welding with Local Preheat and Post Heat*—Permissible on semi-finished castings under special conditions. Should be used only on corners, curved areas, or on such places where expansion and contraction are not restricted.

Defect area must be prepared as for other methods, and preheated to a dull red heat, visible in a dark location, with the gas torch. Welding should be done as described for Gas Welding repair. After weld is completed, operator should continue to play flame over area, gradually diminishing the heat, to provide slow cooling through the critical range.

(B) *Brazing*—Procedure for repair brazing is similar to above, except that a Tobin bronze rod is used for the deposited metal. Repair will be stronger and harder than the nickel repair. Suitable for repair of minor defects in non-critical areas.

(C) *Silver Brazing*—Hard silver solder and similar materials should be used only for individual cases requiring special treatment. Procedures must be determined for each individual case.

(D) *Cast Iron Soldering*—Soldering is permissible for repair of small machined surfaces where structural strength or high temperature is not involved. Solder is of 97.6% Zn, bal. Cu, m.p. approximately 700 F. Strong, uncut hydrochloric acid is the flux, and the solder should be applied with a soldering copper at a dull red heat. Repairs may be finished by filing, machining, or grinding.

(E) *Mechanical Repairs*—For areas subject to compressive or low tensile stresses, plugs or bushings may be permissible. Plugs should be of gray cast iron of approximately the same hardness as the casting, should be taper threaded (SAE Dryseal American Standard Pipe Threads), and so used as to have at least three threads engaged as finished. Both male and female members should be coated with litharge-glycerine sealer. Bolt boss bushings should be so designed as to transmit bolt compressive loads on shoulders adequate to carry loads without creeping. Bushings should be so fitted as to be leak-tight to pressure test after assembly and sealing.

(F) *Peening Repairs*—The use of round-nosed peening tools to close defects in pressure vessels should be confined to "seepers" or "weepers" ("leakers" in which liquid comes through under test pressure at rate of not more than 2 drops per sec.).

(G) *Sealing Repairs*—Use of polymerizing resin sealers for leakers beyond the category of seepers or weepers is permissible when the water comes through as a fine misty spray, not as a solid stream. A pressure of at least 50 p.s.i. must be applied to the cavity filled with liquid sealer. After draining, the casting is baked at a sufficient temperature and for a sufficient time to completely polymerize the sealer. Only those sealers may be used which, after polymerization, resist the action of water, alcohol anti-freeze, glycerine anti-freeze, ethylene-glycol anti-freeze, cooling system corrosion inhibitor, gasoline, lubricating oil, trichlorethylene, Stoddard solvent, kerosene, or other compounds approved by the Procuring Services.

(H) *Rusting Repairs*—Use of sal-ammoniac for rusting up seepers or weepers should be done only by dissolving 10% of sal-ammoniac in the pressure test water and forcing into the porous areas under 65 to 100 p.s.i.

Condensed from Engineering Bulletin No. 152, Society of Automotive Engineers, War Engineering Board

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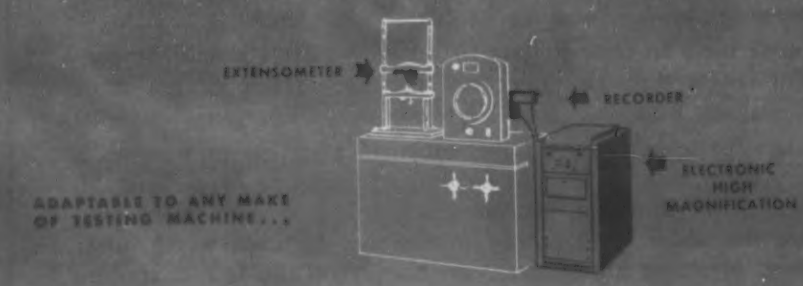

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METALS and ALLOYS

Engineering File Facts

NUMBER 74
February, 1945

GENERAL ENGINEERING DATA
Standardization

"Preferred Numbers" for Standardization

A lesson brought home sharply to engineers during the war is the value of standardization. Standardization of parts makes for lower inventories and facilitates repairs. Standardization of size ranges of products permits greater adaptability with fewer stock sizes. As a basis for a rational selection of sizes, the American Standards Association advocates a numerical series called Preferred Numbers.

The purpose of the preferred numbers is to provide a series based upon a geometrical progression, so that each step will be *proportionately, not equally,* larger than the preceding step. Most companies adopt the idea of proportionality in setting up their size standards, *i.e.*, fractional horsepower motors are standard, but fractional horsepower steps are not carried throughout the entire size range of motors. If a series with five intervals between established high and low limits will provide sufficient gradations to meet the needs of the users, the preferred numbers in the 5-series may be used to establish the individual sizes. In this series, each number is approximately 60% larger than the preceding one. If finer gradations are required, choice may be made of the 10-series, the 20-series, or the 40-series.

When even finer gradations must be adopted than those afforded by the 40-series, there is available an 80-series. With these finer divisions, however, the series tends to lose the characteristics of a geometrical progression and to approach a simple arithmetical progression.

If, after a range of, say, the 5-series intervals has been chosen, it should become advisable to adopt more narrowly divided sizes, the intervening sizes in the 10-series may be added while keeping all the original sizes as standard.

A table of fractional series has also been set up, covering the ⅛-to-1 range in 5-, 10-, 20-, and 40-series; the 1-to-10 range and the 10-to-40 range, each in the four series given. The fractional range from ⅜ to 40 is also covered by an 80-series. However, the fractional numbers have not been widely used, as the decimal series have filled practically all requirements.

Basic preferred numbers are intended as a guide, and may be set aside when conditions demand deviation from the standard. Other series are easily derived from the standard numbers, and these increase the flexibility of the system. These are:

Every 3rd step in the 5-series results in 300% series
Every 2nd step in the 5-series results in 150% series
Every 3rd step in the 10-series results in 100% series
Every 3rd step in the 20-series results in 40% series
Every 3rd step in the 40-series results in 18% series
Every 3rd step in the 80-series results in 9% series

For the designer, preferred numbers offer a means for harmonious design of parts for machines or products in a range of sizes.

Preferred numbers are used as the basis for standardization by many companies in widely diversified lines. Refrigerator capacities, sizes of round cold-rolled steel, mechanical and electrical ratings, ranges of shaft diameter for which fixed machining allowances and tolerances are used, areas of wires in the B. & S. wire gage, proportioning of wage increases, hardness or strength standards, and contents of oil tanks and reservoirs are a few of the objects or properties so standardized. Indeed, the system is applicable to any numerical ratings subject to rational classification.

Inventories of purchased goods may be kept to low levels without decreasing the necessary and required range of sizes by standardizing upon certain sizes in accordance with the preferred numbers system. Such items as nuts and bolts, rivets, screws, pins, etc., are especially adaptable to size standardization on the basis of preferred numbers.

Basic Preferred Numbers—Decimal Series (10 to 100)

5–Series (60% Steps)	10–Series (25% Steps)	20–Series (12% Steps)	40–Series (6% Steps)
10	10	10	10
			10.6
		11.2	11.2
			11.8
	12.5	12.5	12.5
			13.2
		14	14
			15
16	16	16	16
			17
		18	18
			19
	20	20	20
			21.2
		22.4	22.4
			23.6
25	25	25	25
			26.5
		28	28
			30
	31.5	31.5	31.5
			33.5
		35.5	35.5
			37.5
40	40	40	40
			42.5
		45	45
			47.5
	50	50	50
			53
		56	56
			60
63	63	63	63
			67
		71	71
			75
	80	80	80
			85
		90	90
			95

Prepared by Kenneth Rose.
Based upon American Standards Association approved American Standard Preferred Numbers.

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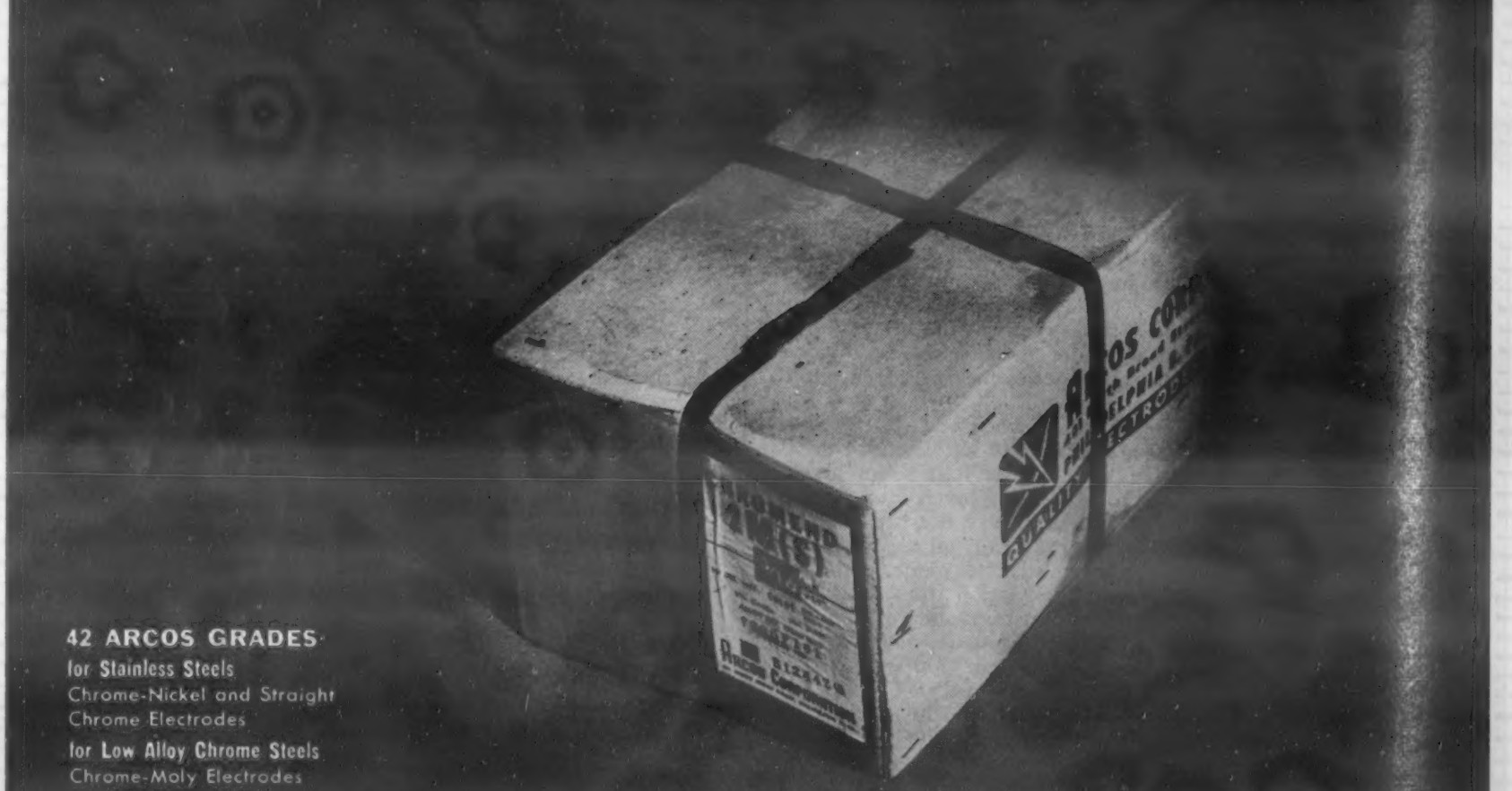

42 ARCOS GRADES

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Manganese-Moly Electrodes

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Houston, Texas...Champion Rivet Co. of Texas
Kansas City, Mo..Welders Supply & Repair Co.
Kingsport, Tenn.....Slip-Not Belting Corp.
Los Angeles, Calif.....Victor Equipment Co.
Milwaukee, Wis.....Machinery & Welder Corp.
Moline, Ill.....Machinery & Welder Corp.
Montreal, Canada..G.D.Peters&Co. of Canada, Ltd.
New Orleans, La.....Wm. D. Seymour Co.
New York, N. Y.....H. Boker & Co., Inc.
Oklahoma City, Okla..Hart Industrial Supply Co.
Pampa, Texas.....Hart Industrial Supply Co.
Pittsburgh, Pa.....Williams & Co., Inc.
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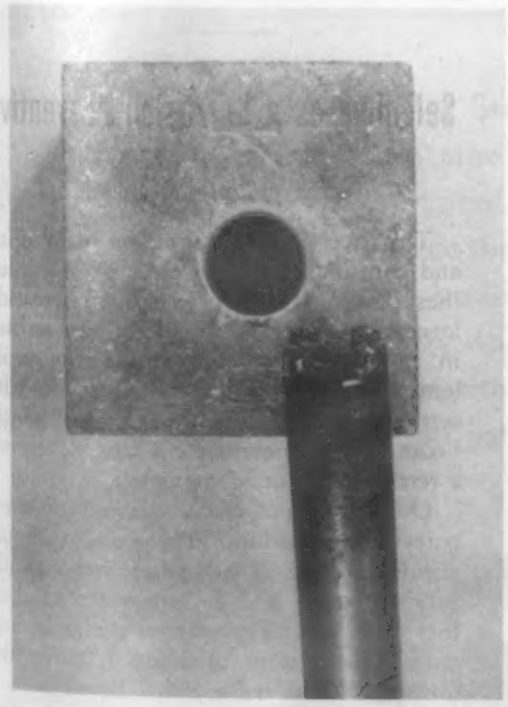
engineering SHOP NOTES

Hard-Tipped Steel Pipe for Drilling Ceramics

by K. J. Trigger,
University of Illinois

The drilling of holes through fire brick or similar ceramic material presents a problem that may be very perplexing to many concerned with furnace maintenance. We were recently confronted with the necessity of drilling several 1⅜-in. diameter holes through a 5-in. thick replacement furnace lining. Four of the holes were to emerge tangent to the inside diameter of the lining, and proper alignment was deemed highly desirable.



Star drills were suggested, but were considered unsuitable, and finally the following drilling procedure applied: A standard taper shank (No. 4 Morse) was turned parallel for 2 in., leaving a square shoulder. One end of a 10-in. length of 1-in. extra strong steel pipe was bored under size for a press fit on the shank. At the opposite end four slots ¼-in. wide by ¼-in. deep were milled on two diameters at 90°. Four recesses ⅛-in. deep, ¼-in. wide, were then milled adjacent to the previous slots. Deposits of a hard facing consisting of 10 mesh tungsten carbide particles in a mild steel jacket (Stoody tube borium) were arc welded into each recess only, the ¼-in. slot being left for "chip" space. Since great accuracy was not required, the welded deposits were not dressed.

The assembly was mounted in a radial drill and adjusted to 125 r.p.m., giving a peripheral speed of 45 f.p.m. The holes were located through the steel furnace jacket and drilled by hand feed of a rate of approximately 1 in. per min. The elapsed time per hole, 5 in. deep, was from 6 to 7 min., including the backing out of the drill for removal of the drillings. All drilling was done dry.

In evaluating the drilling method described, compare the rate with that of a previous experience wherein a 2-in. diam. hole drilled by means of a rock bit and a slurry of 80 mesh carborundum required somewhat over 2 hr. for a 4½-in. depth of hole.

In order to test the special drill on other ceramic materials, several grades and types of brick were drilled. The original drill was used in all tests, the holes being 1⅜ in. diam. in each brick. The results of the tests appear in the table. The end of the drill and a sample of the work (Korundal brick) are shown in the photograph.

Table of Drill Performance

Type of Brick	*Thickness In.*	*Overall Time Min.*	*Drilling Rate In./Min.*
Firebrick	2½	3	0.835
Red building brick	2-5/16	6½	0.356
Kaolin brick	2½	2.65	0.942
"Korundal" brick (90% Al_2O_3)	2½	12.80	0.195

"Overall time" includes cleaning of drillings as well as the actual drilling operation.

A drill, such as that described, may be prepared at little expense in a few minutes. Slot sizes and spacing may be varied, but the spacing should be even to avoid excessive side thrust. The method described is recommended as an accurate and inexpensive way of drilling various ceramic materials wherein the cost of more expensive drill bits is not justified.

The accompanying photograph of the drill and the experimental brick, magnification ⅝ X, is by courtesy of R. E. Cramer.

Forming With Self-Locking Blocks

by Edward Uhl,
Glenn L. Martin Co.

Heavy extrusions and bent-up sections are now being formed in slightly more than half the previous time needed, while production has been increased 68% at

the Glenn L. Martin Co., Baltimore. Previously, the male form block that was attached to the ram on the arbor press was clamped to the work with two C-clamps.

Under the new method, a steel block with a dove tail slide is attached to the ram, having been reworked from previous form blocks so that they can be fitted into the slide. This self-locking form block eliminates the locating, holding and clamping previously required. Now the operator can work the arbor press with one hand while working the part back and forth with the other.

Carbon Flue for Corrosive Gases

by Richard L. Sigerson,
J. M. Mathes, Inc.

Gases from furnaces and testing tables in a laboratory are dissipated through a brick chimney running up through the center of the building. Because of the corrosive action of the gases on the chimney brick it was decided to construct flues of corrosion resistant carbon pipe to carry the gases and protect the brick. Thus was put to use the knowledge of the property of carbon and graphite in resisting practically all corrosive fluids and gases.

The novel installation has been made in the new laboratory building of the St. Lawrence Alloys & Metals, Ltd., Beauharnois, Quebec. It was realized that unprotected brick work would result in periodic repairs from corrosion. Moreover, corroded bricks would permit seepage of gases into the building. Again, if indiscriminately released, the noxious gases would have constituted an explosion hazard, as they contained ammonia, ether fumes, ethyl acetate, etc.

Two flues of corrosion resistant carbon pipe, 8 in. inside diam., were built into the chimney, so constructed as to prevent mixing of explosive combinations of gases. Metal hoods over furnaces and tables, connected to the flues, carry ammonia, hydrochloric acid, ether and ethyl acetate gases into the No. 1 flue. Carried into No. 2 are hydrofluoric, sulphuric, nitric, perchloric acid and chlorine. The gases are exhausted through the flues mechanically. To minimize condensation and a liquid backdrip of acid solutions that might be caused by rain or snow at the chimney top, roofed chambers with side outlets are built of carbon brick.

The bottom of each flue consists of a slanted carbon disc covered with a built-up layer of carbon cement. In case of condensation of acid in the bottom of the flues, the liquid will flow out through a small carbon pipe spillway directly under the inlet section, when the carbon dripcock is opened.

Each flue is 31 ft. high and is formed of threaded lengths of carbon pipe. Joints are sealed with carbonaceous cement with the female threads upright, hence immune to seepage. The National Carbon Co., Inc., who furnished the carbon materials, predicts maintenance-free service of the flues for at least 30 years.

Spring Support for Rod Grinding

by H. Rennie,
Punching, Tool & Die Division,
General Electric Co.

A spring steady rest, devised by the author at G. E.'s Schenectady plant, successfully eliminates vibration while grinding small diameter rods to extremely close tolerances. It has greatly reduced spoilage.

The upright spring, attached to the end of the base by a bridge clamp, rests against the center of the rod under pressure, supporting the work. The bridge clamp is used to avoid weakening the spring with screw holes, otherwise necessary.

The screw used to adjust the pressure

of the spring has a spherical end composed of a steel disk and a leather pad, the latter giving a cushioning effect between the two metal parts and absorbing vibration through the spring.

Chromate-Impregnated Felt Gaskets

by M. J. Turner,
Newell-Emmett Co.

Designed originally to replace scarce rubber, felt, impregnated with a chromate pigmented compound, makes a gasket superior to rubber in some respects. It is fire and corrosion resistant, whereas

rubber does not resist heat and flame. The new gaskets, made by Sherwin-Williams Co., can be used as joint seals in water, fuel oil and diesel oil systems, and for air lock and refrigerator doors.

Chromate gasketing can withstand relatively prolonged exposure to salt water. The chromate pigmented compound is non-drying, tack and water insoluble, and renders the felt flexible, pressure resistant and flame resistant. It will maintain air pressures up to 25 p.s.i. at normal temperatures. It is not affected by fuels and has definite rust inhibiting properties. It is dark green in color and in two thicknesses, 1/8 and 1/16 in.

Usually, chromate gasketing has sufficient adhesiveness to hold it in place without the use of additional material. Sometimes it is advisable to coat the metal flange with a zinc chromate paste.

Selenium as a Corrosion Preventive

by W. C. Clark,
Canadian Copper Refiners, Ltd.

The question of corrosion prevention and control is a prime topic of discussion these days. Our company, the world's largest producer of selenium, has assisted in solving several hitherto vexing problems. One in particular had to do with certain parts of airplane engines which, because of temperature changes, developed a terrific amount of corrosion.

Our engineers coated several of these parts with selenium. These and an equal number of uncoated parts were totally submerged in a 3% salt water solution for 110 hr. Thereafter, the selenium coated parts were unchanged, while the untreated parts were pitted heavily.

These and other tests, such as coating of steel prior to painting, have opened new and wide fields for the use of selenium which hitherto has been used principally in photo electric cells and rectifiers, as well as the ceramic industry.

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Effects of High Temperature Solders on Copper

by R. H. Bailey,
Fairchild Camera & Instrument Corp.

Proof that commonly-used high temperature molten solders have destructive effect on copper wire has been discovered by engineers of the Fairchild Camera & Instrument Corp. Tests with small diameter copper wires show the need of rigid temperature control and, to a lesser degree, close attention to solder composition, in the hot tin dip method of tinning or soldering wires.

The life of fine wire, dipped in any solder, is lessened with increasing solder temperature. Low temperature solders, from the melting point to 600 F., should be used for tinning and making joints on wire sizes finer than 0.0063-in. diam.

High temperatures are more destructive to wire if the tin content of the solder is too high. The life of the wire is greater if lead content of the solder is higher. Unfortunately, however, an all-lead solder results in a considerably weaker solder joint than tin-lead solders.

For a given solder composition and temperature, the finer the wire diameter, the shorter is the wire life in the solder. The all-around best solder is the 40-60 combination, known as soft solder. Embrittlement may be imparted to copper wire from tin-lead solders in the 1000 F. temperature range.

The greatest rate of change in destruction time occurs between 550 and 750 F. for 60-40 and 40-60 solders, and between 650 and 950 F. for pure lead. However, this is compensated for by several factors. Thus, the time needed for tin dipping is short, a matter of seconds, compared with the destruction time. The nearer to the melting point of the solder that this dipping is performed, the better, because time spread is greater.

This destruction of the copper is believed to be an alloying away, or driving into, solution of the copper largely by the tin and to a smaller degree by the lead There is a surface to subsurface coarsening of the copper crystals in 1050 F. solder dipped wire. Moreover, a new hard constituent has been formed, which is the contributing factor to fatigue failure.

Removing Broken Taps Speedily

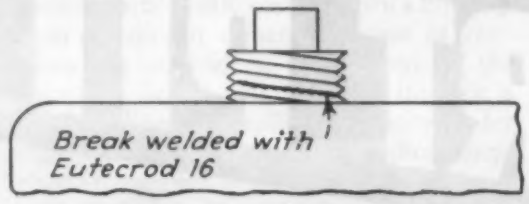
by R. S. Arnold,
Eutectic Welding Alloys, Inc.

[Several methods and types of equipment have been described in the technical press in recent months for removing broken drills and taps—an important war production problem. So here is one more.—Editor.]

Broken taps are a headache. In some cases, the work is scrapped and at other times the damaged tap is laboriously removed by drilling, chipping or a screw extractor—all costly, time-wasting procedures. One Eastern plant was especially chagrined by the frequent loss of valuable bottoming taps. The usual methods were tried, but with only occasional success.

Finally the company found a successful method. Autochemic Eutector Flux, No. 16, was painted on the end of the tap broken in the work and on the end of the loose half. The two surfaces were "tinned" with EutecRod No. 16 and clamped together.

An oxyacetylene torch was carefully directed at the joint until the molten alloy



showed uniformly around the joint. As soon as the alloy solidified the broken tap was easily withdrawn. This No. 16 rod bonds to steel at 1300 to 1600 F., having a tensile strength of 160,000 p.s.i. in this type of joint.

This procedure has enabled the plant to save hundreds of dollars worth of taps and irreplaceable man-hours.

Nitrogen gas absorption into furnace fixtures has been a serious drawback in heat treating involving nitriding for high surface hardness. Often the fixtures absorb nitrogen, adversely affecting the necessary high concentration of gas. Fixtures made from metals low in nickel content suffer particularly. They not only absorb needed gas, but deteriorate rapidly. One maker of airplane engine crankshafts, therefore, uses in nitriding a "Nichrome" fixture made by Driver-Harris Co. that contains 60% nickel.

International Nickel Co.
—"Nickel Steel Topics," June 1944

Controlled Atmosphere Furnace Brazing

by A. K. Phillippi,
Westinghouse Electric & Mfg. Co.

Controlled atmosphere furnace brazing is a method for joining metals together with various brazing alloys in an atmosphere which prevents oxidation of the parts being brazed and reduces slight oxides that are present. Among the benefits of this process are: Assemblies come out clean; distortion is minimized since parts are evenly heated and cooled; the product is better; a reduction in cost results; there is a minimum of production inspection and servicing of the product in the field; expensive machining operations are eliminated; waste of metal common to machining is absent; less material need be purchased; less chips and turnings need be handled by the salvage department.

This method of fabricating sheet metal parts and screw machine parts is increasingly used in modern manufacturing. The simplicity of design of the parts to be joined makes it adapted to the fabrication of the majority of punch press parts, turned parts and many intricate assemblies.

It is often not used due to lack of concrete knowledge of its possibilities and economies. Many makers of typewriters, adding machines, etc. now furnace braze. Usually when one of their machines is returned to the plant for repairs it is found that the part has worn out and not come loose at the joining. To have success one must start with the design of the pieces to be fabricated.

Each part should hold its proper relations to other parts of the assembly while being heated to 2050 F. and while cooling, both without the use of fixtures where possible, since fixtures absorb some of the B.t.u.'s away from the work. Wherever possible the design should provide for putting the pieces in shear and having as much metal as possible contact all other pieces that are to be joined. Thus where a tube passes through a 1/16 in. plate and must be brazed to it, rather than just drill and ream the hole, the hole should be swaged, giving approximately twice the thickness of material that contacts the tube.

Various methods keep all members in contact: Resistance welding, tacking with an arc, riveting and press fit. Copper, the commonly used brazing alloy with steels, when wet, will by surface tension or capillary pull, penetrate into a joint and wet both members. Tests have shown that the 0.002 in. press fit gives the strongest joint. The greater the press fit, the more time needed for the copper to penetrate the joint. The amount of copper needed can only be determined by experiment

Brazing furnaces generally consist of a charging chamber, heating chamber and a cooling chamber, and should be so built that room atmosphere will not enter and ruin the controlled atmosphere. As to atmospheres, some partially burn the gases and use the balance as an atmosphere, while others merely crack various gases and produce a combination of atmospheres which are used with various grades of steel.

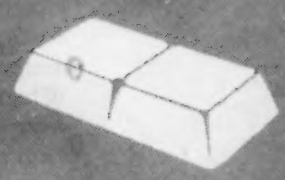
If welders' visors, goggles and window shields are coated with lacquer, protection is secured against scratch burns. With lacquer, glasses have been used for five weeks in a welding test. After this period the accumulated flux was removed with thinner and the glass treated again with lacquer. In continuous spot welding, it was sometimes necessary to change welders' glasses three times a day because of scratch burns, when lacquer was not used.

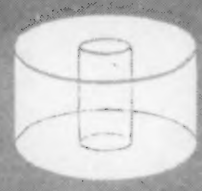
—Lafean Stine & S. Cyril Erler, York Safe & Lock Co.

Metal-Working Industries

Edited by Kenneth Rose

Engineering Editor,
Metals and Alloys





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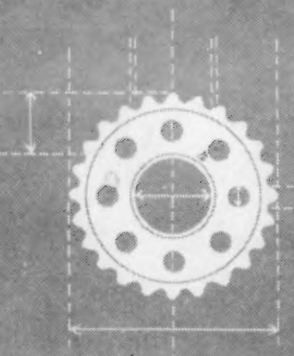

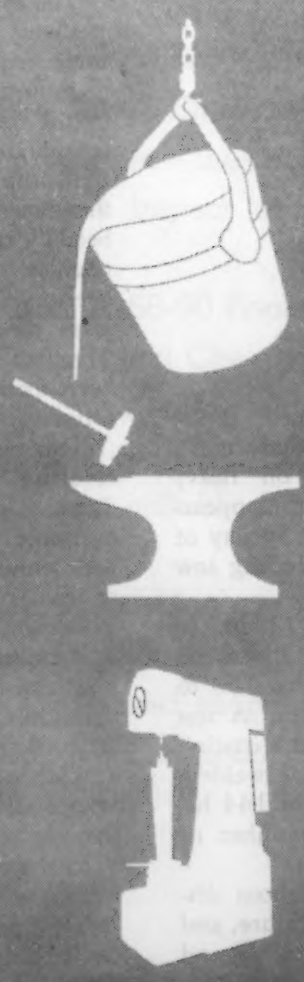

ENGINEERING DIGEST

A selection of outstanding articles on engineering materials and processing methods

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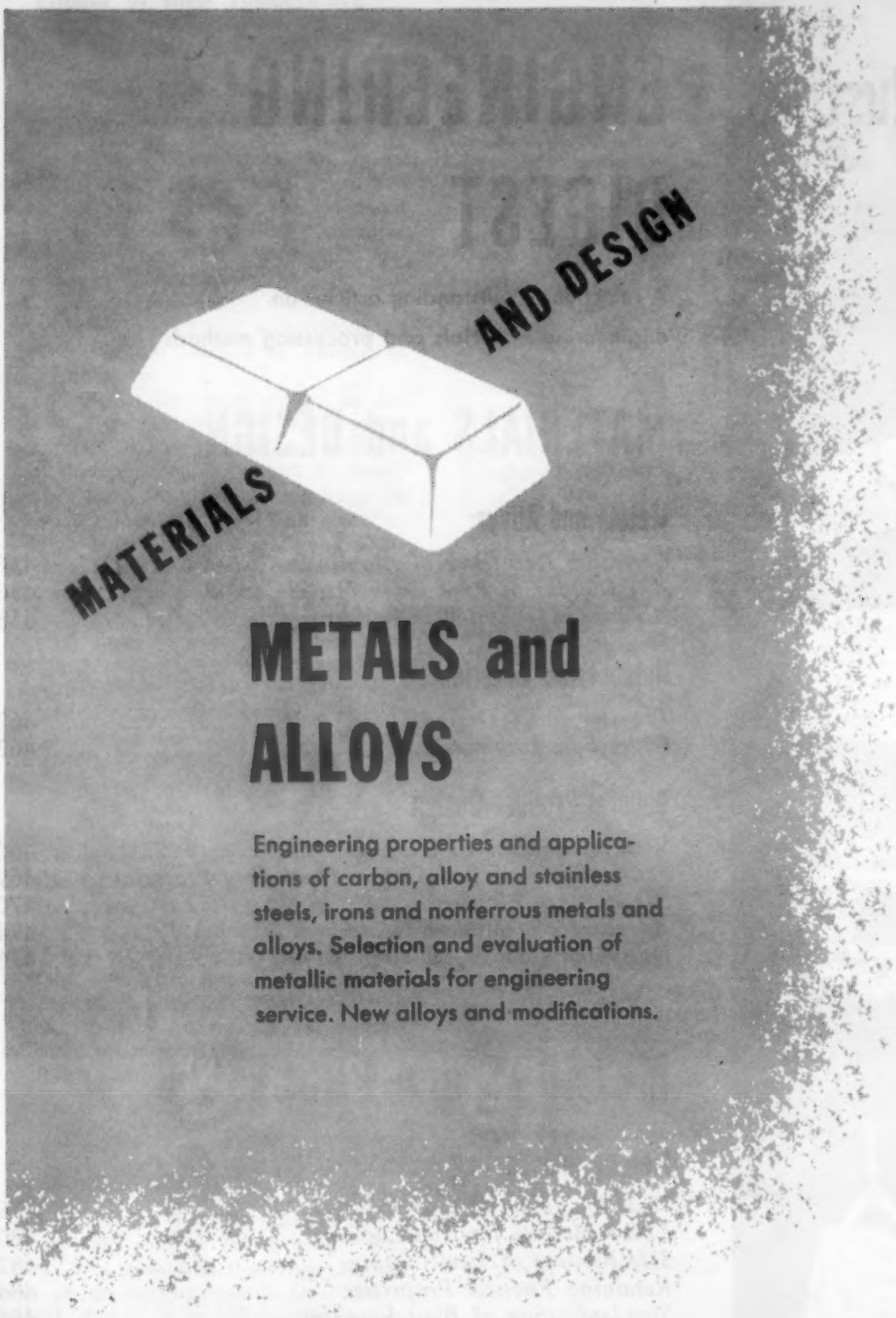

MATERIALS
AND DESIGN
METALS and ALLOYS
Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.

Corrosion Resistance of Aluminum-Coated Steel

Condensed from "Product Engineering"

Aluminum-coated sheet steel can now be produced economically by the American Rolling Mill Co. They have advantages over coatings of zinc, tin and lead, especially as to resistance to heat, corrosion and oxidation. It has high heat reflectivity, attractive appearance and strength of steel.

Post-war applications are automobile mufflers and exhaust pipes, domestic range ovens, containers of all kinds, reflectors for lighting fixtures, etc. It has replaced stainless steel for certain aircraft parts requiring heat resistance.

In applying the aluminum over steel, one lightly oxidizes the cold-reduced sheet, reducing the thin oxide with hydrogen, which protects the clean sheet as it is led beneath the aluminum coating bath. Another bonding method provides undercoating of zinc, the result being a spangled appearance.

When aluminum is coated on heavy sheet, followed by rolling, it has the appearance of pure aluminum sheet. A variety of base metals can be supplied, including low carbon and copper steel.

The coating is applied 0.0012 in. to 0.0018 in. thick on each side of the sheet, the weight of the aluminum being 0.60 to 1.00 oz. per sq. ft. for both sides. A test in 20% salt spray at 95 F. showed a coating life of over 500 hr. When spot welded, corrosion at the welds appeared in 144 hr. but they had not increased in number or area after 250 hr.

It withstands up to 900 F. without discoloration. Even at higher temperature, and with some alloying, it does not scale and still resists heat.

Good Reflectivity

Heat and light reflectivity are the same as for solid aluminum and is slightly better than No. 7 finish on 18-8 stainless steel and far superior to porcelain enamel finish; hence, good for electric oven liners. Moderate forming and drawing can be done without flaking or peeling, standing bending 180 deg. around a diameter twice its thickness.

Boeing reports: "It forms well in parts requiring only slight deformation, but is not suitable for severely formed parts due to excessive cracking, flaking and peeling of the corrosion-resistance coating."

Heat treatment was found to increase the adhesive bond between coating and base metal, and has been included in the production process. Forming dies should be designed to avoid scraping the coating. When tensile specimens were pulled to destruction, the aluminum coating moved uniformly with the metal base and no flaking was observed.

Small surface cracks appeared throughout the coating, though not detrimental to corrosion resistance. Tests indicate that aluminum coatings provide similar galvanic protection to zinc, but are more durable.

In spot welding, it compares favorably with 18-8 steel, except that the most probable shear strength is lower in direct proportion to the ultimate tensile strength of the materials. However, three times more spot welds can be made on 18-8 between electrode cleanings. The new coating will hold paint better than galvanized sheets.

—*Product Engineering*, Vol. 15, Nov. 1944, pp. 762-765.

Applications of Rare Earth Metals

Condensed from "Metallurgia"

The impetus to study the 14 closely allied elements called the rare earth metals has come mainly from the ceramic industry. The metallurgical industry has been discouraged by the difficulty in maintaining a supply of comparatively pure metal.

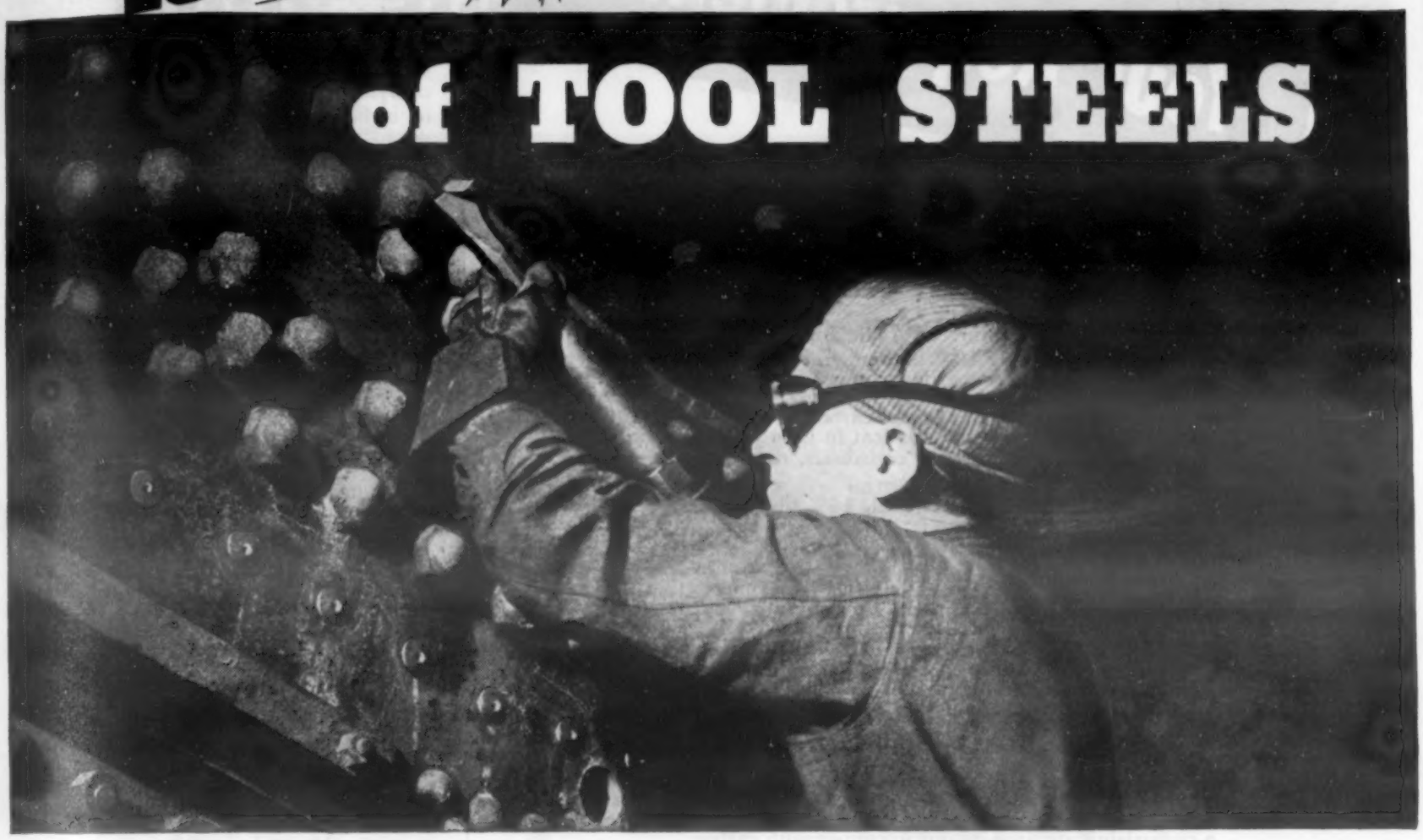
In the ceramic industry, the ability of these metals to absorb ultra violet rays has been extensively exploited in welding goggles. Cerium and didymium salts have been used mainly, as 2 to 4% Ce_2O_3 makes glass completely absorbent to ultra violet. The irradiation properties of cerium have been utilized to some extent in fluorescent tubes with mercury vapor lamps.

The rare earth metals are also used for coloring and decolorizing glasses. Neodymium gives the only bright purple color available. A combination of cerium and neodymium overcomes the undesirable color of iron.

Cerium oxide has been substituted for manganese in glass for X-ray work, as such glass resists coloring for a longer time. Neodymium and praseodymium are used in artificial gems, especially rubies. Cerium dioxide can be substituted for tin dioxide in opacifying enamels, but it is too expensive for general use.

In the metal industry, cerium is the most widely used. As it is pyrophoric, cerium is applied for lighter flints and tracer shells. Cerium as misch metal is a very active getter for gases in electronic vacuum tubes.

SHOCK TROOPER of TOOL STEELS



Years of experiment and development work have endowed Bethlehem Omega Tool Steel with tremendous shock-resisting properties—the ability to withstand drastic and repeated impact at normal temperatures.

Its normal working hardness is 58-60 Rockwell C; at this figure, it possesses an unusual Charpy impact value. Under test, it shows considerable elongation and reduction of area. This combination of hardness, toughness, and ductility makes it suitable for a wide variety of applications.

Omega was developed primarily for use in cold-battering tools and for machine parts that are obliged to withstand severe shock. It is used successfully in pneumatic chipping chisels, hand chisels, punches, shear blades, cold-forming dies, calking and flue-beading tools, and all other tools in which the ultimate in shock resistance is required.

If you haven't used Omega, we suggest you give it a test under your most unfavorable conditions. Don't baby it, don't coddle it. Give Omega the works. We think you'll agree that it can take punishment.

BETHLEHEM STEEL COMPANY, Bethlehem, Pa.
BETHLEHEM STEEL EXPORT CORPORATION, New York City

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OMEGA... one of Bethlehem's BIG 8 Tool Steels

Which of These Alloys Meet Your Requirements?

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① **MICHIANA Fire Armor. 65% Nickel, 20% Chromium.**
DESCRIPTION AND USE. A high grade heat-resistant alloy possessing superior properties in certain high temperature applications where corrosion is also a factor. Its high Nickel content also increases its resistance to carbon absorption. This alloy has proved particularly economical in long cycle applications.
TYPICAL USES: Carburizing containers, retorts, furnace parts and fixtures, salt pots.

② **MICHIANA Zorite. 35% Nickel, 15% Chromium.**
DESCRIPTION AND USE. High strength at elevated temperatures. Is the most universally used grade in the field of heat treatment. Along with other high Nickel alloys, it is not recommended for use in the presence of sulphurous atmospheres; but under practically all other conditions, this grade shows remarkable durability and therefore economy.
TYPICAL USES: Furnace parts such as rails, beams, supports, rollers. Also carburizing containers, annealing boxes, salt pots, retorts, trays, fixtures, magnesium retorts, etc.

③ **MICHIANA No. 100. 25% Chromium, 12% Nickel.**
DESCRIPTION AND USE: This alloy has superior qualities under certain high temperature corrosion conditions particularly where sulphurous gases are present. It is only slightly inferior to Zorite from standpoint of strength at high temperature. Because of its greater affinity for carbon it is not recommended for use in a carburizing atmosphere nor in contact with carbon.
TYPICAL USES: Much the same as indicated for Zorite with the exception above mentioned. Also as indicated it would be preferred in the presence of a sulphurous atmosphere.

④ **MICHIANA No. 48. 28% Chromium, 8% Nickel.**
Similar to No. 100, having somewhat higher resistance to sulphurous atmospheres at high temperature. This composition does not fall within the stable Austenite formula however.

⑤ **MICHIANA No. 55. 33% Chromium, 3% Nickel.**
There are a few heat-resistant applications where a high Nickel content is detrimental. An example of this would be where Copper, which has a high affinity for Nickel, comes into contact with such an alloy at high temperatures more particularly above 1600° F. Also in some cases, detrimental catalytic action has resulted from a high Nickel content.
In these instances, the above alloy would be specific, but it will be understood that in all cases, the maximum permissible Nickel would be used to minimize other detrimental effects of low Nickel.

ARMY E NAVY

Further details and many illustrations, design stress tables, etc. are included in our recently published Booklet 110. A copy will be forwarded on request. MICHIANA PRODUCTS CORPORATION, Michigan City, Indiana.

- Muffles
- Boxes
- Rails
- Rolls
- Sprockets
- Retorts

MICHIANA
Heat-Resistant and Corrosion-Resistant ALLOY CASTINGS

- Pots
- Grids
- Tubes
- Chains
- Heat Exchangers

Cerium in cast iron whitens the structure, while in steel it increases the hardenability to a certain extent and has a grain refining action. It is particularly used in alloys for heating elements.

At high temperatures, cerium increases the solubility of hydrogen in aluminum. Cerium additions to Avional and Aldrey decrease the tensile strength and increase the electrical conductivity. In magnesium, cerium increases the ductility and strength. Praseodymium in general forms very hard and brittle compounds in alloys.

The main application of the rare earth metals in the chemical field is as industrial catalysts in the organic field. Cerium fluoride in carbon pencils for arc lamps increases the brilliance of the light.

Biologically, these metals have an orticant effect on the nervous system when inhaled. This may preclude their use in alloys, which must be welded to any extent. Erbium and cerium salts have anti-anaemic properties greater than that of iron, but their adoption for this purpose is not promising, as they are relatively poisonous and increase the blood coagulation.

Cerium iodide inhibits cancerous tissues, while cerium oxalate is occasionally used for sea sickness. In general, the rare earth salts have an antiseptic, tonic and astringent action in the human body, while they increase the yield of fruit.

In textiles, the rare earth salts are used with tin salts to deluster rayon, weight silk, increase the light fastness of dyes and in mordanting.

—R. C. Vickery. *Metallurgia*, Vol. 30, Oct. 1944, pp. 311-312.

Aluminum in Post War Buildings

Condensed from "Light Metals"

The trend that now appears to be shaping in projected applications for the use of aluminum in post-war buildings is discussed. In the past, aluminum has been used in office buildings, hotels and hospitals, but not in private homes. Predictions for its probable post-war use in buildings range from houses made almost completely from aluminum to its use for small components only.

Even if there were an ample supply of conventional building materials, aluminum would be considered because of the labor-saving inherent in its use. It has the added advantages of high resistance to corrosion, low weight, high strength, and a pleasing appearance.

The proper use of aluminum would facilitate pre-fabrication, as large sections could be handled with ease. Such pre-fabrication could consist of complete rooms made at the factory for assembly on the site or of walls, roofs and floors transported as flat panels. Since practical considerations govern the section in many cases, non-heat treatable alloys would usually be strong enough.

Attention must be paid to the fact that for a similar section, aluminum deflects three times as much as steel. The best results will be obtained in designing for aluminum and not in merely substituting aluminum or its alloys for other metals.

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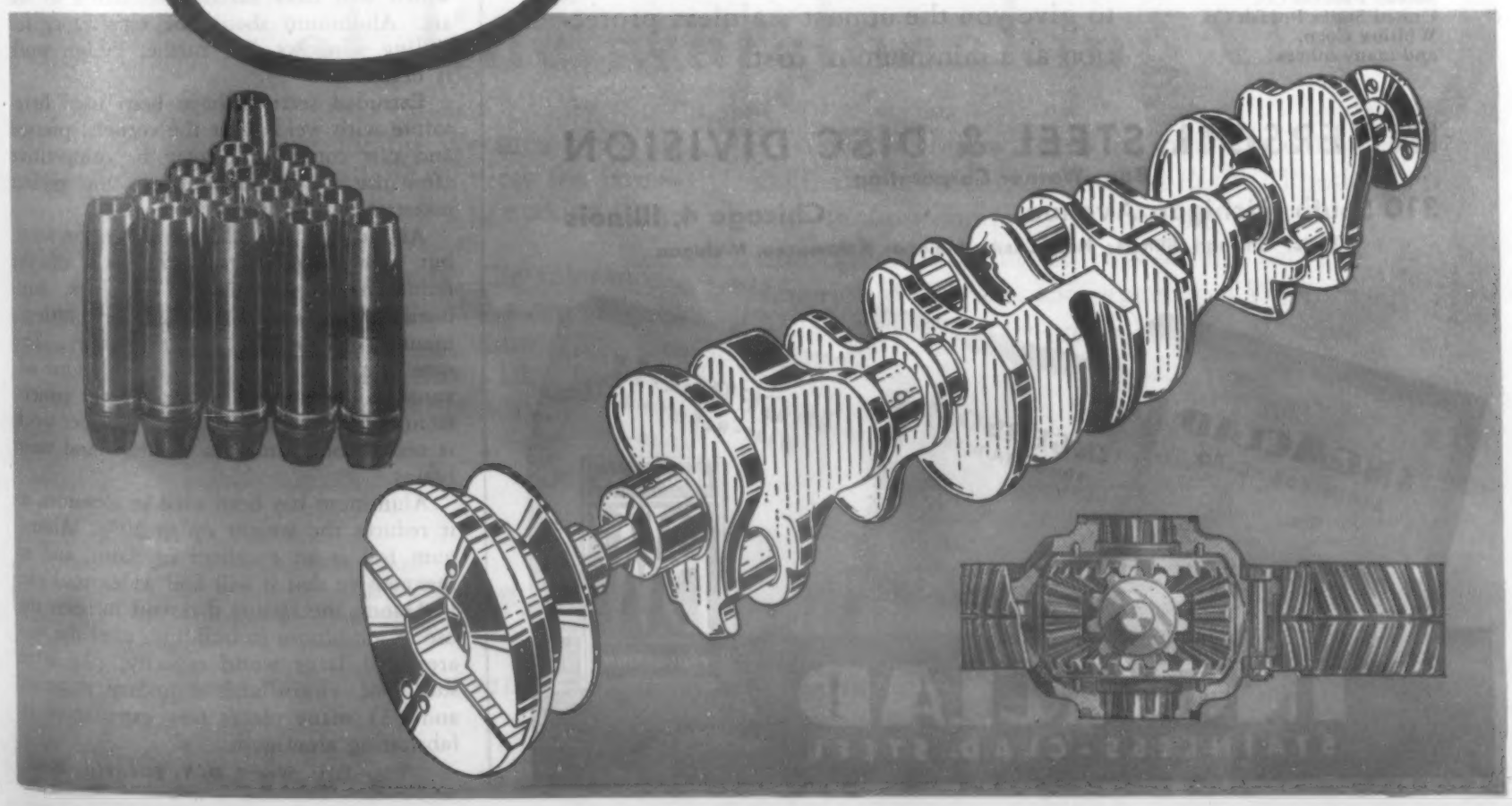

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Aluminum Roofs

The use of aluminum for roofs is not new; an aluminum roof in service for forty years is still in good condition. Tiles, seamed sheet roofs, composite roofing, slabs and boards have been considered, as has the question of the pre-fabrication of a complete roof at the factory. Most of these systems have been devised for use with brick walls; special systems may be worked out which would be better for pre-fabricated houses.

In the case of flat roofs, a composite slab of aluminum alloy filled with an inexpensive insulator, such as sawdust or sawdust concrete, may be useful. The aluminum may be joined by welding, lapping, or special cover junction strips. The use of plastics for jointing is worthy of exploration. In any case, it is desirable to cover as much ground as possible with each piece to minimize the number of joints. Gutters and spouting are preferably of aluminum if the roof is aluminum.

Aluminum has been used for decorative panels but not for partitions, although it would be ideal for sliding walls. If the wall is to carry a load, a heat treatable type of aluminum alloy should be used. Plastic joinings may be particularly suitable. Asbestos may be incorporated in the panel for fire resistance or an insulator to improve the already high thermal insulation. Aluminum walls may easily be cleaned with soap and water, although there may be some fading of dyed anodic coatings.

Advantages for Fittings

Aluminum doors have the advantage of corrosion resistance, fine finish and ease of opening. The latter is especially important with large doors such as in hangars. Aluminum alloy glazing bars have been used for over fourteen years, and are competitive with other materials. Aluminum has also given encouraging service in windows for some years.

It is probable that the magnesium-aluminum type of alloy will be most widely used for this application, as it is the only one which will have suitable resistance to sea air. Aluminum should be satisfactory for sliding windows, but further design work is necessary.

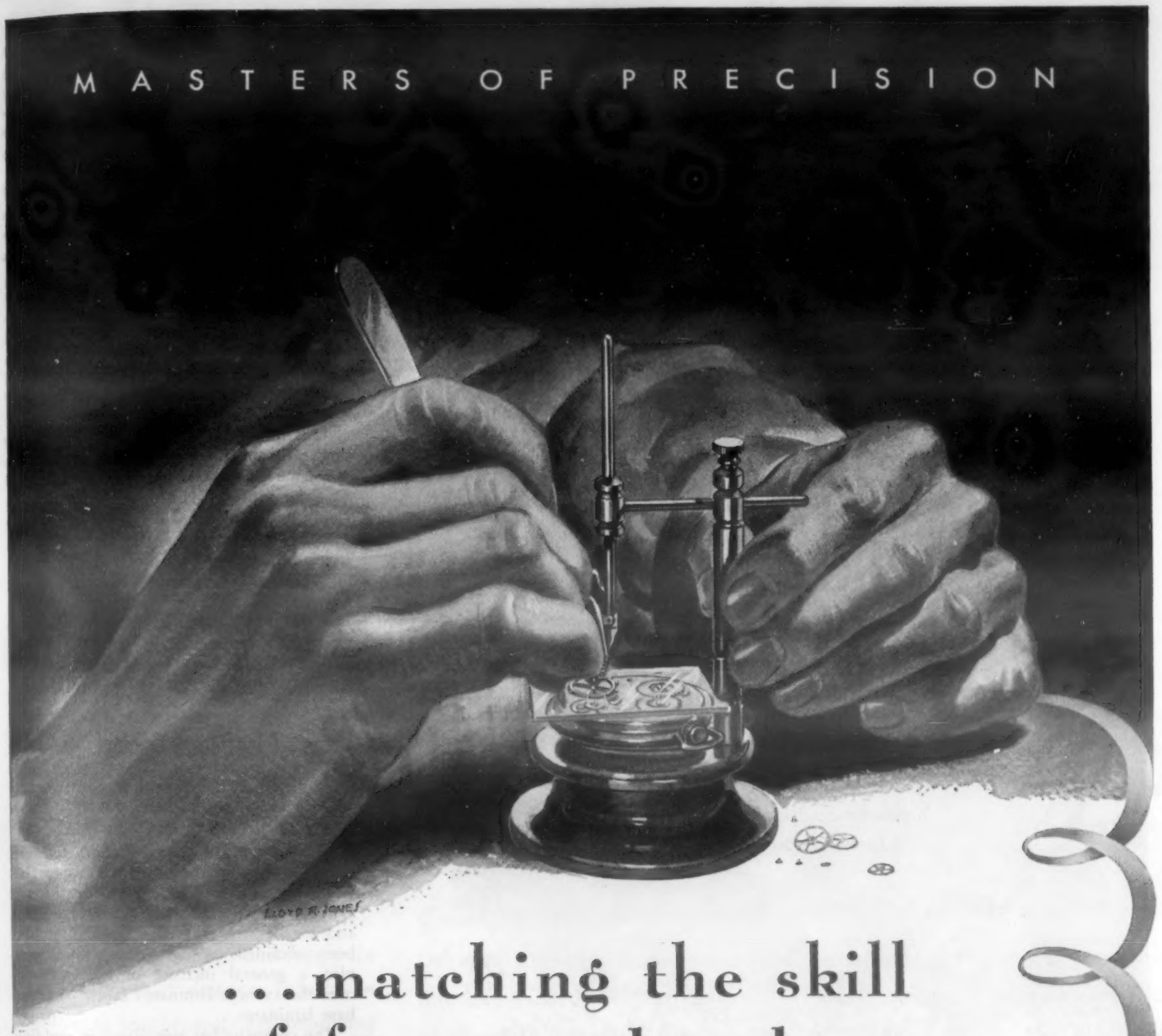
Extruded sections have been used heretofore with welding at the corners; pressed and cast construction may be competitive after the war. Aluminum is the perfect material for canopies.

All-aluminum kitchens may not be ideal, but aluminum alloys fulfill most of the requirements satisfactorily (lockers, cupboards, refrigerators, table tops, fittings, utensils, wall and ceiling panelling). The ease of cleaning aluminum is a decided advantage in its use in bathrooms for panels, facing of shower cubicles, etc. Further work is needed on aluminum bathtubs and wash basins.

Aluminum has been used in elevators, as it reduces the weight up to 50%. Aluminum foil is an excellent insulator, and so inexpensive that it will find widespread use.

Among the factors that will increase the use of aluminum in buildings after the war are: (1) large world capacity; (2) large stocks of virgin and secondary material; and (3) many plants now experienced in fabricating aluminum.

—E. G. West & D. V. Pike. *Light Metals*, Vol. 7, Aug. 1944, pp. 361-369.



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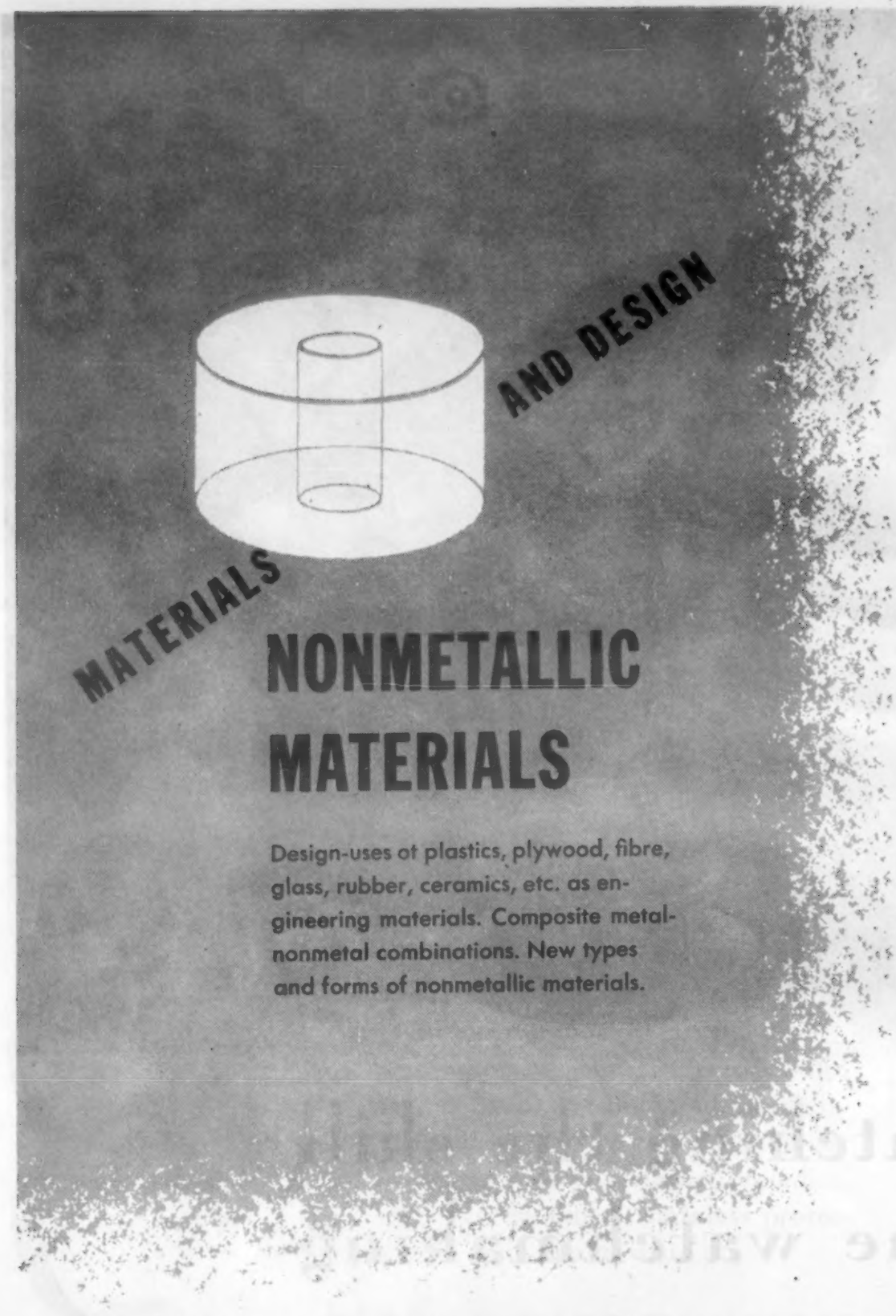
MATERIALS
AND DESIGN
NONMETALLIC
MATERIALS
Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New types and forms of nonmetallic materials.

Transfer Mold Design

Condensed from "Modern Plastics"

Transfer molding is the term applied to molding in which the thermosetting material used is subjected to heat and pressure, forced into a closed mold cavity by this same pressure, and held there under heat and pressure until curing is complete. It offers advantages in the molding of intricate sections, or in the use of delicate inserts, or where small and deep holes are required. Parts may show higher strength, and closer tolerances may be held.

There are several general types of these molds in common use. The loose-plate or hand transfer type, used especially when a group of fragile inserts must be included, makes use of a plate to form the top of the mold cavity. Inserts are fitted into this plate, and the plate placed in the die so that the inserts also engage in the bottom of the cavity.

Gates are located at the perimeter of the plate and the compound is loaded above the loose plate. By using several plates, one can be loaded with the inserts while another is in the die.

Transfer presses prepared with a floating platen having a transfer chamber may use this platen and chamber with all the molds made for use in the press, eliminating the necessity for a transfer chamber and plunger as a part of each mold. The press may serve as a conventional compression press, with the platen acting as a stripper plate.

When the mold is built as a integral unit, having its own transfer chamber and plunger, a gain in efficiency may be shown for many types, since the transfer chamber may be designed for best results with a particular cavity shape. They are made for hand or semi-automatic operation.

In "duplex molding," the molds are similar to the pressure type of die casting die. Combined with high frequency or other improved types of preheating equipment, this type will give highest quality molded parts with maximum production per cavity and per dollar of equipment.

With high frequency or other improved heating, the transfer chamber offers no design problem. Preforms will flow very fast after pressure is applied. Closing times as low as 4 sec. for transfer of a 2-lb. charge have been achieved.

When no preheat is used, the total closing time should be from 30 to 90 sec., and a large part of that time will be used in plasticizing the material. Heating area will be between 5 and 10 sq. in. per oz. of material.

It is important that the chamber area be larger than the combined land area when the same pressure is used for transfer and for clamping. To be sure of adequate clamping, many mold designers lay out the transfer chamber area 25% greater than the land area.

While several chambers may be used in a single transfer mold, loading considerations indicate that the use of only one chamber is preferable.

—J. H. Dubois. *Modern Plastics*, Vol. 22, Oct. 1944, pp. 134-135, 190; Nov., pp. 138-140, 206.

Paper Base Laminates

For Aircraft Structure

—L. H. Ritter, *Plastics*, Vol. 1, Dec. 1944, pp. 30-32.

Development of a high-strength phenolic paper-base laminate for structural use has been announced by McDonnell Aircraft Corp. The material is called Structomold, and tensile strengths of 45,000 p.s.i. have been obtained on parallel-laminated samples, a general increase of nearly 300% over the average laminated fabric or paper-base laminates.

The company has specialized in molding, fabricating and assembling large and complex parts and assemblies, using low-pressure molding on metal dies. By using printed paper or colored paper or resin, color and designs are incorporated into the product.

Specific gravity is 1.35 to 1.4. In the parallel-laminated material, tensile strengths are reported as 35,000 p.s.i. with the grain, and 18,000 p.s.i. across the grain, with compression given as 19,000 and 17,000 p.s.i. for the same condition. The 50-50 cross-laminated material possesses a tensile strength of 25,000 p.s.i. and compression strength of 18,000 p.s.i.

Water absorption of specimens with unsealed edges is 3.4% during 24 hr. total immersion, while sealed-edge specimens showed only 1.2% absorption. The material is unaffected by oil, high-octane gasoline, mild acids, or alkalies.

The material has been used to replace a stainless steel ammunition box, a weight saving of about 40% resulting. A gunner's seat made of Structomold accomplished a weight saving of 43% over a magnesium casting formerly used. Replacing a metal gun shield with one of Structomold permitted a weight saving of 45%.

WORTH GETTING "STEAMED-UP" ABOUT

Designed by Brooks Stevens, molded by Raymond Laboratories for The Spartan Co., Minneapolis

The Spartan vaporizer illustrated above is a brand new development in humidifying equipment. Entirely automatic, this vaporizer holds a full half-gallon of water and gives off steam immediately even though the water is ice cold. The unusual design and ingenious mechanical principle of this unit typify the progressiveness of American industry in developing new products and improving old ones with plastics.

The ever-increasing usage of Durez phenolic molding compounds by manufacturers throughout industry is due directly to two reasons.

First is the unusual versatility of the phenolics. These most versatile of all plastics possess such desirable properties as excellent moldability, highest dimensional stability, diversity of finishes, dielectric strength, and resistance to heat, moisture, acids and alkalies.

Second is the rich background which Durez technicians have acquired through *specializing* in the production of phenolics during the past quarter century. They have participated in the successful development of thousands of different products, supplying in each case a plastic that fitted the job. In many instances, the finished product was not all-plastic but consisted of a combination of plastic and metal. A good example of this is the above illustrated Spartan vaporizer. The lower container, inner elements, knobs and handles were molded from a Durez phenolic compound. The cover is a satin-finish aluminum stamping.

Undoubtedly you are working out the development plans for a product which is scheduled for post-victory marketing. Naturally you are considering the use of plastics in this connection. The benefits of our broad experience plus the wealth of data collected in our files are at your disposal at all times. Durez Plastics & Chemicals, Inc., 272 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

MOLDING COMPOUNDS

INDUSTRIAL RESINS

OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB

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IRON POWDER

STEEL POWDER

A Complete Plant Produces Iron Powder With Characteristics Particularly Suited To

POWDER METALLURGY APPLICATIONS

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▲ High Sintered Strength
▲ High Rate of Flow
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AMERSIL*!

3092°F
MELTING POINT

2700°F
FOR SHORT PERIODS

2100°F
CONTINUOUSLY

COEFFICIENT OF EXPANSION IS 0.000000054 PER DEGREE OF C.

Amersil* (fused silica) possesses many advantages over all other materials when used in the fabrication of many pieces of chemical and industrial plant equipment.

It withstands, operating temperatures of 2100°F. with peaks up to 2700°F. permissible for short periods. Its coefficient of expansion is 0.000000054 per degree of C. over a range of 0° to 1,000°C. This is 1/34 that of copper, 1/17 that of platinum, 1/9 that of tungsten. It is inert to acids, even when hot and concentrated—except hydroflouric (at all temperatures) and phosphoric above 270°F. and is unaffected by the halogens, with the exception of flourine. It does not contaminate the acids handled. It withstands severe thermal shocks, is light in weight and provides unique electrical insulation values.

A new Amersil* Catalog is now on the press. Write today—on your business letterhead, please—and reserve a copy.

*The registered trade name of the only American manufacturer of a complete line of fused silica products.

AMERSIL COMPANY Inc.
A Subsidiary of Nichols Engineering & Research Corp.
60 Wall Tower New York 5, N. Y.

Another plane part made successfully from this laminate is a gun turret floor assembly, with an ammunition guard incorporated. It is almost 50% lighter than the original metal part. An aluminum rim around the top of the assembly is fastened to the plastic by means of rivets and screws.

New Laminate Described

—E. C. O. Erickson & George E. Mackin, Paper, *Am. Soc. Mech. Engrs.*, November 1944 meeting.

A new laminated paper plastic, called Papreg, has been developed by E. C. O. Erickson and George E. Mackin, of the United States Forest Products Laboratory. The material has been found suitable for use in non-structural aircraft parts and for other commercial uses.

Papreg is prepared from resin-impregnated paper, and has a specific gravity of about 1.4 at a resin content of about 35%. It has a smooth, hard surface, and reasonable decay and moisture resistance. It lends itself to low-pressure molding techniques, and has been satisfactorily post-formed to moderate double-curvature.

Development work included investigations of the influence of such variables as wood species, pulping processes, papermaking procedures, type and amount of resin, and molding conditions on the properties of Papreg. Data on the physical and mechanical properties of differently constituted and processed material were obtained.

Tensile strength of the paper from which the laminate is made may differ greatly between machine direction (grain lengthwise) and the cross direction of the sheet. This difference in strength is reflected in the strength of the Papreg.

It can be made with the grain direction of all the sheets in the same direction (parallel laminated), or with alternate sheets at right angles to each other (cross laminated). Parallel-laminated Papreg has tensile and flexural strengths of 36,000 p.s.i. in the lengthwise direction, and 20,000 p.s.i. for tensile and 24,000 p.s.i. in flexural strength in the cross direction.

If the material has been prepared in the cross-laminated manner, strengths are intermediate between that for the two principal directions of the parallel-laminated product. The greatest deficiency in mechanical properties is in toughness and ductility. Strength properties increase with decrease in temperature, but show a general decrease as temperature rises, similarly to cellulose-filled phenolic compositions and plastics.

Papreg shows a 10 to 15% increase in moisture content upon long-time exposure to high humidity or to immersion. In all cases increased humidity results in some loss in strength and stiffness, as well as increase in dimension. These effects are characteristic of all cellulose compositions.

In Papreg, the stiffness is the least affected by humidity variations, even a 10% gain in moisture content at 97% relative humidity causing little dimensional change except in thickness. The increase in thickness, in the direction of molding pressure, is approximately equal to the percentage change in weight.

Encouraging results were obtained in the use of low molding pressures. It was found possible to use pressures as low as 50 p.s.i. Although always desirable, low-pressure laminating is particularly important when large sections are to be prepared.

Touch Comfort

is an important quality of

LUMARITH* PLASTICS

Nearly everyone will agree that our homes, automobiles, all the things we use and enjoy should have a welcome touch . . . and that statement immediately suggests what can be done toward this ideal with Lumarith Plastics.

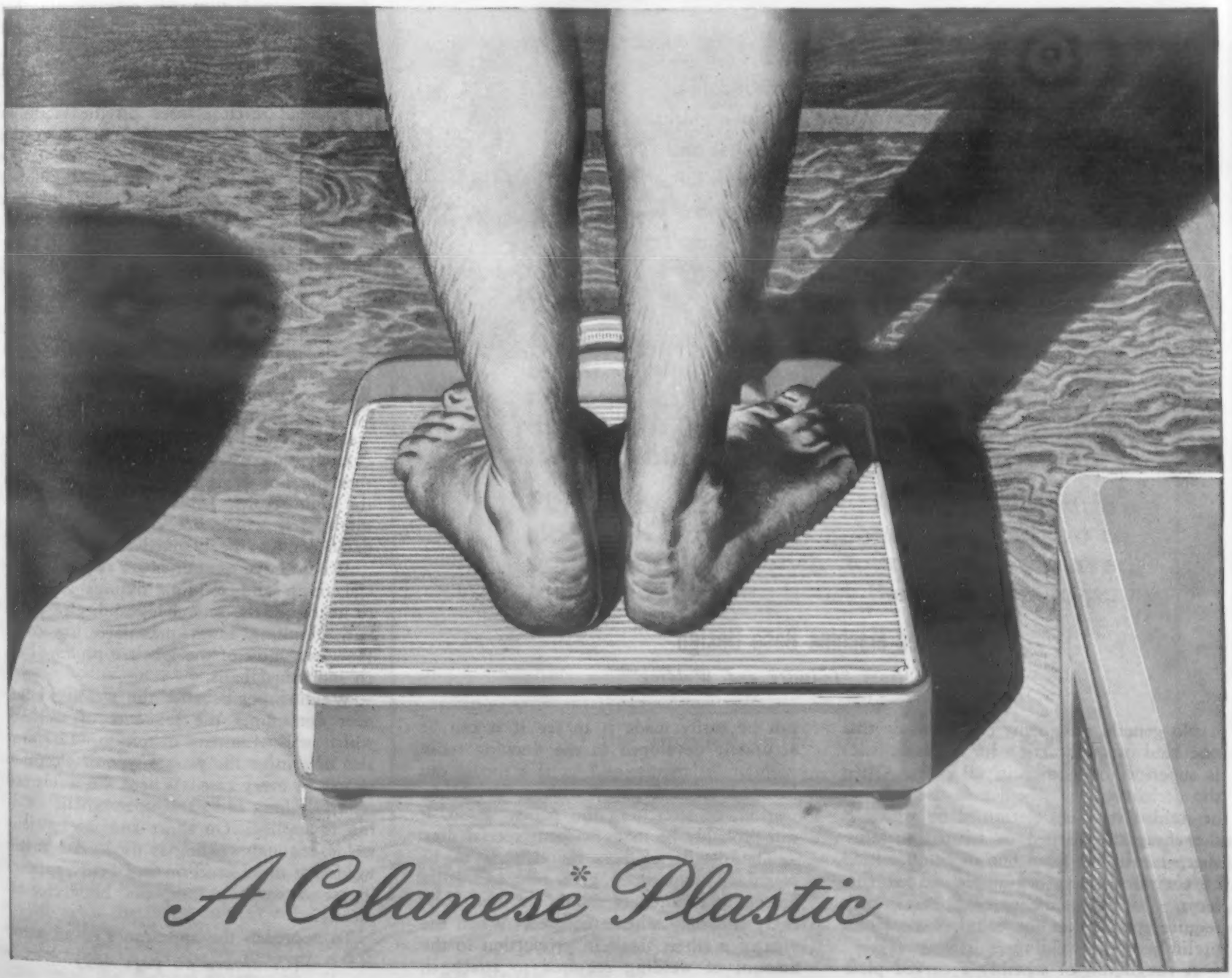
Of course, this isn't an argument in favor of the all-plastics home or postwar automobile . . . far from it. It is merely a reminder of the touch comfort to be had from Lumarith, and a reference to the many places where these Celanese* Plastics make the things we touch "feel better".

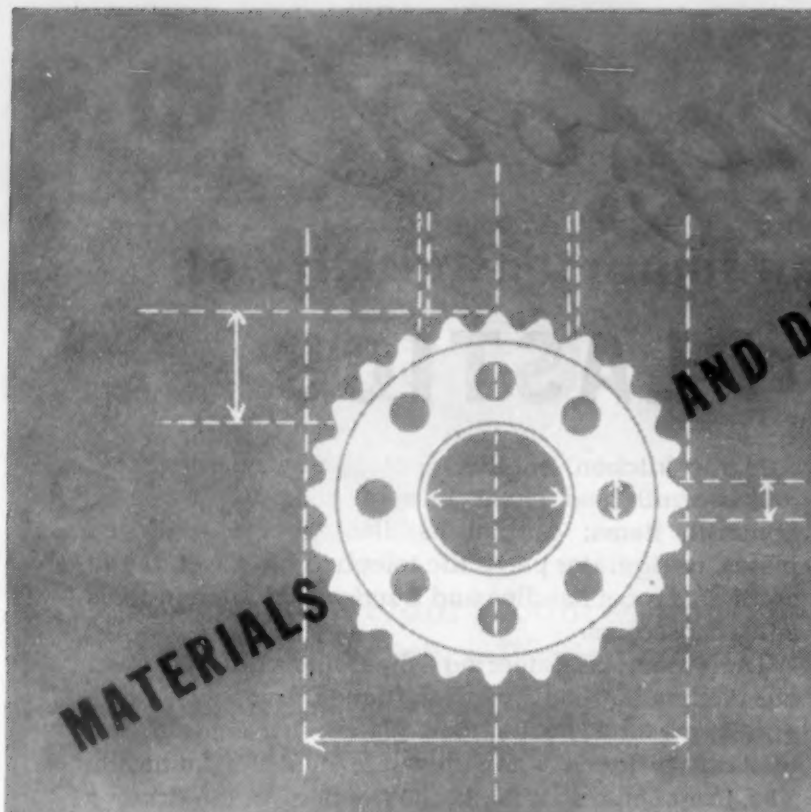
In the bathroom, for example, Lumarith articles moderate the chill of porcelain and tile: seat covers, switch plates, wall fixtures, towel bars, scale platforms, clothes hampers, door knobs—all the contact points between a home and its occupants.

*Reg. U. S. Pat. Off.

And the kitchen, another spot of breezy efficiency, gets warmth and cheer through the liberal use of Lumarith items: cabinet handles, door and switch plates, refrigerator parts, the telephone handset, range controls, faucet handles and hundreds of kitchen tools and accessories.

The automobile steering wheel and controls—even our clothes buttons, eyeglass frames, compacts, cigarette cases and pocketbook clasps are smooth and pleasant to touch when they are made of Lumarith. Yes, from cellar to attic, at the office or in the driver's seat, the things we touch should bring us comfort. That is what Lumarith plastics are designed to do. Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, New York.





GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

Welded Machine Base Design

Condensed from "Industry and Welding"

No general statements can be made that one kind of construction for machine bases is superior to another in all cases. Often the decision as to whether to use castings or welded steel is determined by which is the cheaper. Warped or twisted surfaces, sharp transitions from one to another kind of curved surface, or double curved surfaces, such as elements of spheres, may require special dies for forming the plates preliminary to welding.

A rough test of whether a curved plate can be easily made is to see if it can be accurately developed in the drawing room without "triangulation," or if a model can be made of stiff paper without wrinkling, tearing, or stretching the paper. If so, it can probably be made without special dies.

The details of bosses and pads to be machined sometimes give trouble. Ribs, gussets and stiffeners should be used sparingly and only where required. When the area of a rib is small in proportion to the amount of welding required to attach it, it is very expensive. Sometimes, if the thickness of the plate is increased to get the required strength and the stiffeners are omitted, the job will be cheaper and better looking.

The details of the footings are often determined by the necessary details at the anchor bolts. Where no gust strength is required, holes in the bottom flanges may be sufficient. A stronger and more easily made detail results from attaching the flange to the side of the base than welding the side to the top of the flange. When the bolt holes are inside the general area of a box-like base, using a pipe is advantageous.

Use Low-Carbon Steel

The major part of material used in fabrication by welding is low-carbon steel plate, as specified in A.S.T.M. Standard A-7-42 or A-10-34. Medium manganese steels, low-alloy, high-tensile steels, and high-carbon steels are used in many cases where added strength or special qualities are needed to improve the design characteristics.

Also, material should be selected with regard to its weldability and machinability. Carbon should preferably be below 0.30% and sulphur not more than 0.05% to assure improved machinability and sound welds without special techniques.

Where castings or forgings are to be used with the plate, the composition of the former should approach very closely that of the plate for welding characteristics. Castings should be pre-machined, X-rayed, or gamma-rayed to assure sound metal before welding.

A hand torch is used on the assembly floor for final trimming, but the automatic flame cutting-machine is used for all accurate cutting. Intricate patterns and straight cutting can be duplicated easily on this machine.

The majority of long, straight outer edges in lighter gages are better sheared than flame cut, whereas all heavier gages and internal cut-outs must be flame cut. Circular patterns are cut by rotary shears. Beveled joint edges in lighter gages may be sheared; in heavier gages, they must be flame cut or machined.

In preparing special plate edges, the weld kerfs or bevels must be machined accurately to assure joint efficiency. Neither shearing nor flame cutting will accomplish the same results. Large quantities of duplicate parts, which are costly to shear or flame cut, can be blanked readily.

Where large quantities are required, special fit-up and welding fixtures are used to guarantee the interchangeability of parts, with resulting lower manufacturing costs. However, most of the jobs are produced on an individual basis.

Welding begins after the welding engineer determines the sequence of welding which will eliminate distortion. He must also determine the proper type of electrode to use in every case. Where the welds are relatively long and straight, automatic welding is applied. On short and intermittent welds, manual welding is used. Automatic welds are more uniform and better appearing, and welding time can be decreased greatly.

To approach the appearance of an auto-

(Continued on page 469)

matic weld in manual operation, special positioners are used. These produce a more uniform weld because of the advantage of a down-hand welding position.

—F. L. Lindemuth & F. C. Kardevan. *Ind. & Welding*, Vol. 17, Oct. 1944, pp. 66, 68-69, 71-73; Nov. 1944, pp. 35-36, 88-90.

Fatigue Strength and Surface Hardening Processes

Condensed from "Metal Progress"

The use of induction or flame hardening for highly stressed machine parts may cause trouble with fatigue failures, due to trapped tensile stresses in the hardened layer and to reduced hardness of the adjacent non-hardened material.

The fatigue strength of machine parts is increased when the regions that are stressed in tension by the operating loads are residually stressed in compression. This is particually true for parts loaded in bending or torsion. Although residual stresses are often considered undesirable, this is due to a lack of understanding as to how to utilize them properly.

Compressive pre-stress may be obtained by mechanical manipulation (pre-setting of springs, shot blasting, tumbling and, sometimes, straightening) or by heat treating (carburizing, nitriding, induction hardening, flame hardening and severe quenching). The improvement in fatigue strength caused by these treatments is largely a matter of proper residual stress pattern; however, improper residual stress patterns can also be obtained.

Carburized parts, for example, are fatigue resistant because the strength of the outer layer is increased and because this layer is highly stressed in compression due to thermal contraction of the outer layers on quenching and to the increased volume of the hardened layer. A carburized gear showed a compressive stress of about 90,000 p.s.i. in the surface layers and a tensile stress of about 50,000 p.s.i. in the core. Shot peening increased the compressive surface stress to 150,000 p.s.i.

The sequence of events is reversed in flame heating and induction heating. The net surface residual stress in such surface hardened steel is the sum of the tensile stress produced by the thermal contraction and the compressive stress produced by the transformation. Test pieces measured have shown a compressive surface stress of about 30,000 to 40,000 p.s.i.

However, immediately below the hardened layer is a softened layer subjected to quenching but not heated high enough to transform subsequently. This layer will, therefore, be very highly stressed in tension in service, since the stress in this zone is the sum of the tensile stress from the external load and the residual tensile stress resulting from the thermal contraction. If

IN PRECISION INSTRUMENTS IT'S DIE-CASTING, TOO

Partial View of Foxboro Temperature Controller Assembly Line

Eloquent testimony to the accuracy with which intricate and minute metal parts may be die-cast is found in the manufacture of Foxboro Temperature Controllers.

As a time factor, too, The Foxboro Company has discovered the advantage of die-casting, not only in the greater volume of parts produced per hour but in the release of labor for machining operations formerly necessary.

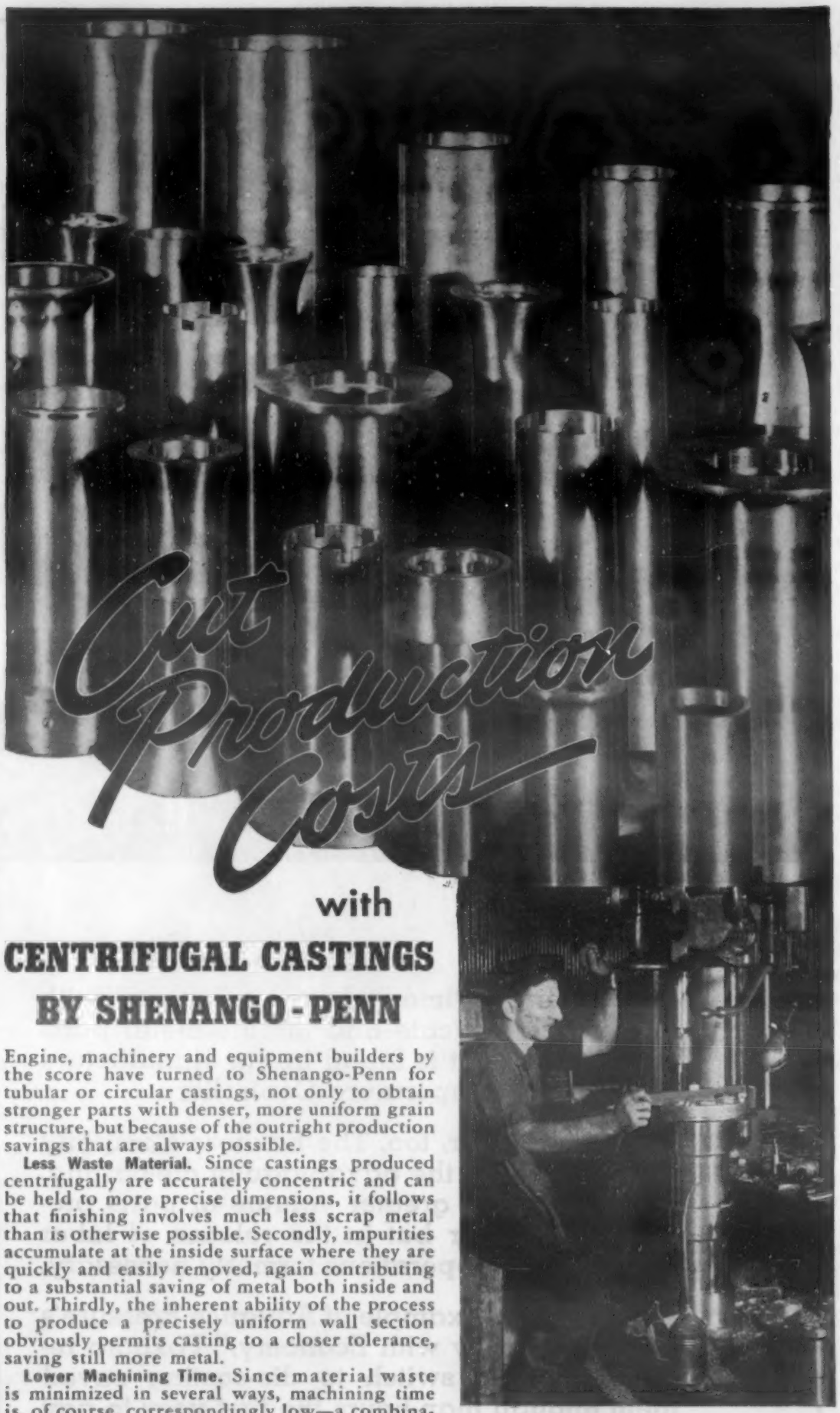
Finally, as an example of Advance Pressure's slogan "Quality with Economy," Foxboro reports that the switch to die-casting saved them enough man-hours the first year to pay for the intricate dies.

Your inquiry, with sketch or blueprint, involves no obligation

ADVANCE PRESSURE CASTINGS, INC.

Engineers, Designers and Manufacturers of Die-Castings of "Quality with Economy"

48 North 15th St. Brooklyn 22, N. Y.



with

CENTRIFUGAL CASTINGS BY SHENANGO-PENN

Engine, machinery and equipment builders by the score have turned to Shenango-Penn for tubular or circular castings, not only to obtain stronger parts with denser, more uniform grain structure, but because of the outright production savings that are always possible.

Less Waste Material. Since castings produced centrifugally are accurately concentric and can be held to more precise dimensions, it follows that finishing involves much less scrap metal than is otherwise possible. Secondly, impurities accumulate at the inside surface where they are quickly and easily removed, again contributing to a substantial saving of metal both inside and out. Thirdly, the inherent ability of the process to produce a precisely uniform wall section obviously permits casting to a closer tolerance, saving still more metal.

Lower Machining Time. Since material waste is minimized in several ways, machining time is, of course, correspondingly low—a combination saving that is attractive indeed.

Bulletin 143 gives complete information about Shenango-Penn centrifugal castings including other advantages and specifications of the various available alloys. Write to the Shenango-Penn Mold Company, 1353 W. Third Street, Dover, Ohio.

In addition to foundry facilities, Shenango-Penn is well equipped for all kinds of machining and finishing operations. Here flanges of bronze castings are shown being drilled.

ARMY NAVY SHENANGO - PENN

ALL BRONZES • MONEL METAL • ALLOY IRONS

this second zone is exposed (*e.g.* where local areas are hardened as on crankshafts), it is doubly vulnerable because it is then subject to the added stress raisers of surface irregularities.

Nitriding, carburizing or severe quenching do not form such second zones because the heat flow is different and because there is no annealed material under the hardened layer.

The formation of second zones can be minimized in induction hardening by using very high frequency equipment with a high power input to give a satisfactorily hardened case at the root of the tooth and to decrease the width of the second zone. Likewise, local hardening or junctions between previously heated and newly heated sections should be avoided.

In flame hardening, the temperature gradient is lower than in induction hardening, so that the second zone effect can not be decreased to the same extent.

—J. O. Almen. *Metal Progress*, Vol. 46, Dec. 1944, pp. 1263-1267.

Alkyd Resin Finishes

Condensed from "Metal Finishing"

One of the most important developments in metal finishing promises to be the expanding use of alkyd resins. This type of resin has attained wide wartime use in lusterless olive-drab enamels, in camouflage paints for seagoing vessels, and for aircraft finishes. Government figures show that in 1943, 52½ million lb. of glycerine were used in the manufacture of synthetic resins. This is more than went into the manufacture of explosives.

Chemically, alkyd resins are the reaction products of polyhydric alcohols and polybasic acids, of which glycerine and phthalic anhydride are typical. These resins are usually modified to obtain special properties for specific purposes, by the addition of oils, fatty acids, natural resins, or other substances.

Alkyd resins possess many advantages. They have toughness, flexibility, and color-retentiveness. They withstand high baking temperatures. They have good adhesion to metals, and withstand water, grease, abrasion, and impact. These properties have led to extensive use of this type of finish for automobiles, refrigerators, and on sheet metal, where the finish will withstand drawing and forming operations.

Alkyd resins are used in metal primers where their good adhesion is an important factor. In primers, they serve as a base for corrosion inhibiting zinc chromate and zinc yellow. These pigments are more effective in an alkyd resin vehicle than in linseed oil.

Recent patents describe the use of alkyd resins in compositions for making flexible, adherent insulation on copper wire.

(Continued on page 474)

Consider Powder Metal Parts and Porous Bearings in the following applications:
ELECTRIC MOTORS • VACUUM CLEANERS • SEWING MACHINES
BLOWERS and FANS • KITCHEN MIXERS and DOMESTIC MACHINES • CLOCKS • REFRIGERATORS • WATER PUMPS
BUSINESS MACHINES
And Many Others

IN THE DESIGN OF NEW AND IMPROVED PRODUCTS

Specify KEYSTONE POWDER METAL PARTS

★Postwar products now on planning boards, in many cases, will call for the redesign of various metal parts. Because of our many years of research and experience in the processing and molding of metals and anti-friction materials, we can produce by powder metallurgy precision molded metal parts to meet your requirements.

Many of these parts could formerly have been produced only by tedious hours of machining, milling, slotting, grinding and drilling. Keystone's Powder Metallurgy process will produce them economically and at a higher rate of speed while maintaining closer tolerances than machine made parts. Because of their uniformity, hand fitting of each piece is eliminated. Compression molded parts will increase production in many plants at great savings in cost, just as they are doing in many war plants.

Numerous metals are now available for production such as copper, iron, bronze, brass, nickel, steel and combinations of the above. Other metals are rapidly being added to this list. Write for booklet "Keystone Powder Metallurgy."

POWDER METAL PARTS DIVISION

KEYSTONE CARBON COMPANY, INC.

MANUFACTURER OF PRECISION MOLDED PRODUCTS
1935 STATE ST., SAINT MARYS, PENNA.

BRONZE to STEEL to ABSCO-MEEHANITE

Replacing the stainless steel which had succeeded nickel bronze, these ball connections of Absco-Meehanite are serving as flexible joints in locomotive steam lines from boiler to booster engine. They are used in superheated steam service up to 250 lbs. pressure, up to 450°F. While these castings incorporate most of the properties listed below, their pressure tightness, corrosion resistance and machinability recommend them especially for this service.

ABSCO-MEEHANITE PROPERTIES

1. Strength (Shear, Compressive, Tensile and Transverse)
2. Impact Resistance
3. ✓ Corrosion Resistance
4. Wear Resistance
5. Heat Resistance
6. Toughness
7. Rigidity
8. ✓ Machinability
9. ✓ Pressure Tightness
10. Vibration Absorption

Meehanite castings permit close control of physical properties for your specific application. Write for Meehanite Engineering Handbook

AMERICAN Brake Shoe COMPANY

BRAKE SHOE AND CASTINGS DIVISION
230 Park Ave., New York 17, N. Y.
3924

Alkyd resins are also used extensively mixed with other resins. Thus, mixed with urea-formaldehyde resins, a vehicle with the advantages of short baking period, extreme hardness, marproofness, and light fastness is obtained.

These finishes, both white and colored, are widely used for refrigerators, hospital equipment, metal kitchen cabinets, etc. Mixed with melamine aldehyde resins, a rapid curing finish with superior color and gloss retention is obtained.

—Georgia Leffingwell & M. A. Lesser. *Metal Finishing*, Vol. 42, Nov. 1944, pp. 718, 720-721.

Advantages of Modern Gearing

Condensed from "Western Machinery and Steel World"

Spur gears, bevel gears and chain sprocket wheels for power transmission were in use 4000 years ago. Early peoples had a sound knowledge of basic principles of toothed gearing and different tooth forms, such as the involute, cycloid, etc. The old-fashioned wooden mortise toothed gear was sound, but it needed the development of the synthetic Phenolithic materials to make a satisfactory non-metallic gear.

Toothed gearing has never been ousted by alternate methods. It has an efficiency of over 99%. Gears are successfully applied to airplane superchargers at 30,000 r.p.m. and to cement mixers at the other end of the speed scale. No matter how old the gear, its full efficiency lasts, a fact that makes watches and clocks practical.

Gears are also positive, having no slip. They satisfy the needs of big gun controls, astronomical telescope mountings, gages, speedometers, etc.

Its main fault is noise, though this has no relation to power loss. Transmission drives competing with gears never have an efficiency of over 95% at best. With belting, power loss may be enormous. Modern gearing will carry hundreds of times more horsepower and at hundreds of times faster speed than would have been thought possible 50 years ago.

One important requirement for silent operation is accuracy, meaning adequate modern machinery to cut the gears and teeth, though this does not always guarantee silence. In some cases celeron, Bakelite, etc. makes for silence, though they will not carry the load of steel gears. Meehanite has proved an ideal material for gears.

In the case of plain cast iron gears, there is apt to be a spongy internal structure at the junction of sections, where the strength is required. Moreover, with cast steel there are weak spots in the form of shrink defects where there is a junction of sections.

In the case of both gray iron and cast steel the use of chills will largely eliminate the defects, but this is expensive and not always practical. Meehanite castings shrink but little during solidification and are uni-

Super-resistant

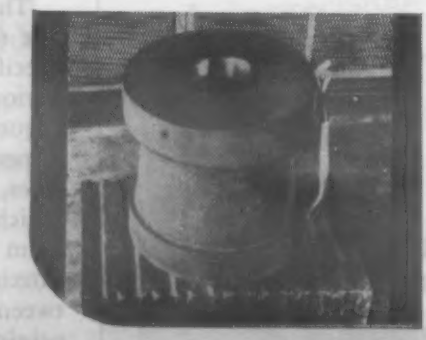
to Wear and Failure

Centrifugally-cast parts of Ampco Metal lengthen life of machinery...

Only from Ampco can you get *all* of these services and benefits:

1. Distinctive properties of resistance to wear, impact, fatigue, corrosion.
2. A series of engineered alloys — with physical properties to fit your application.
3. Quality control to hold these properties within narrow limits.
4. Diversified production facilities — coordinating in one place all the commonly used metal-working processes.
5. Engineering and production "know-how" to give you a practical manufacturing program.
6. A nation-wide organization of field engineers to assist you.
7. A record of proved performance in hundreds of leading makes of equipment.
8. A national reputation that makes Ampco Metal parts a sales asset.

To the basic advantage of Ampco Metal—its exceptional resistance to wear, shock, fatigue, and corrosion — the centrifugal casting process adds plus values. Cast under pressures 50 to 300 times as great as in sand casting, Ampco centrifugally cast parts are the practical equivalent of "liquid forgings"—100% sound (avoiding costly rejections), closer to finished size (saving metal). The Ampco organization furnishes all types of machining . . . rough, semi-finished, or ready for assembly . . . fabricated from an engineered alloy under close metallurgical control. . . . Let Ampco's broad facilities and experience play a constructive part in planning your post-war product. Write for bulletins and services of a competent field engineer.



AMPCO Metal

Specialists in engineering, production, finishing of copper-base alloy parts

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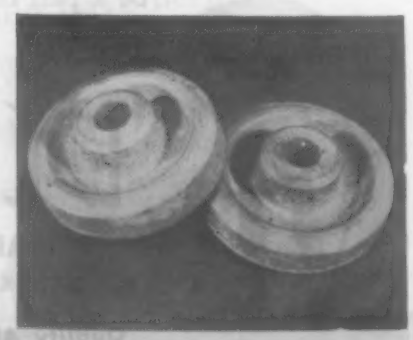


titan's

brass pressure die castings

are Still at War

America's production facilities are still being called upon to supply our armed forces with the vital materials needed in their drive to total victory. Titan's entire production of Brass Pressure Die Castings have been, and will continue to be devoted to this purpose until the war has been brought to a successful conclusion.

Titan's Brass Pressure Die Castings will again be available for the new era of better living which will be a part of our postwar world.

Titan

METAL MANUFACTURING CO., BELLEFONTE, PA.

NEW YORK • CHICAGO • SAN FRANCISCO

Quality Alloys By Brass Specialists

Brass and Bronze Rod • Forgings • Die Castings • Welding Rods

formly solid, regardless of mass influence, and use of chills is unnecessary.

The strength of Meehanite castings is much greater than usual for ferrous castings, and compares favorably with some cast steels. Type GA Meehanite is 40,000 p.s.i. in conjunction with a compressive strength of 175,000 p.s.i. and a yield point of 47,200 p.s.i. By proper heat treating, tensile strengths of over 70,000 p.s.i. and a hardness of 550 Brinell may be attained.

The modern precision roller chain on highly accurate cut sprockets now prove a splendid answer where noise of spur gearing and low efficiency of belting would be intolerable, with efficiency well over 99%. Hence, chain can be used where not thought possible 12 years ago.

—E. W. Gaunt. *Western Machinery & Steel World*, Vol. 35, Nov. 1944, pp. 486-488.

Designing Sheet Metal Aircraft Parts

Condensed from "S.A.E. Journal"

One of the most important aspects of design for production of sheet-metal parts is the formability of the parts. The various types of forming consist of one or more of three classes of strain: elongation, compression, or a combination of the two.

The problem of the formability of sheet-metal parts involves the determination of the working limits of elongation and compression under various conditions and how to design within these limits. There should be available the results of up-to-date experiments that will show the upper limits on elongation and compression for all the various forming conditions under which they occur, for various materials, and for all types of tools and equipment that may be used.

An analytical approach is given to the problem of designing within the working limits that have been set, by means of examples of its application to forming of curved flanges, beads, flanged holes, and joggles. By means of the equations derived for the first three cases, the amount of elongation or compression called for by the design may be computed directly from the dimensions given by the design.

The analytical method has a limitation, but this can be overcome by studying the specific local distribution of strain in the various types of formed parts. The technique consists of applying by photography a network of either rectangular or polar lines, rather closely spaced, to the blank which is to be formed. The strain resulting from forming can then be measured approximately by comparing the spaces between lines on the formed part with the original spacing on the blank.

—Frank M. Mallett. *S. A. E. Journal*, Vol. 52, Nov. 1944, pp. 526-533.

Forging Assignments Licked with "Es"

EXPERIMENT

EQUIPMENT

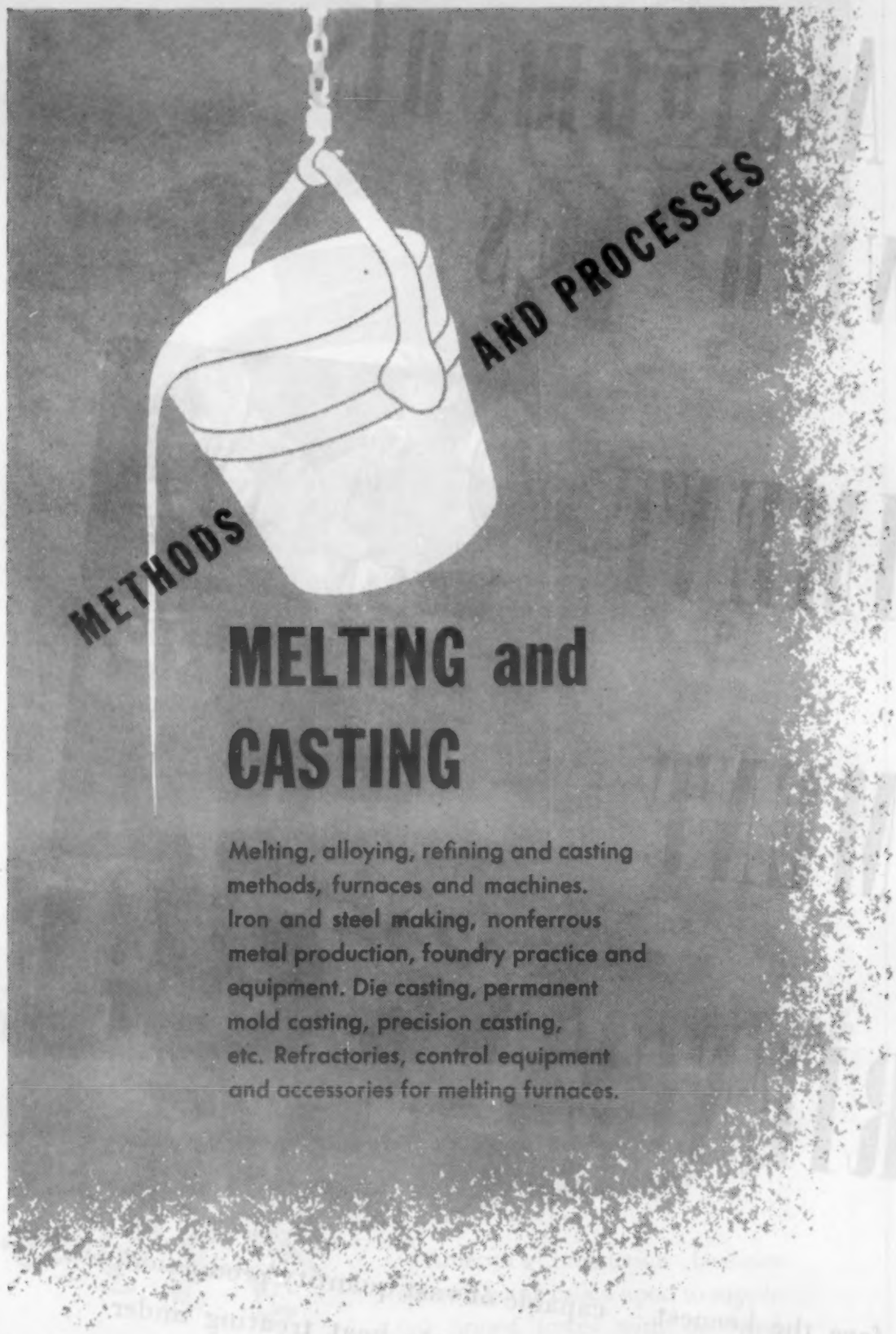
EXPERIENCE

Your product will face the keenest competition in history when this war is over. You are now studying ways to improve it to meet that competition. Forgings of steel or light metals may provide the answer, in weight saved, in added strength, in precision.

Tube Turns will welcome your inquiry. Complete laboratory facilities and a resourceful engineering staff are at your service. Our equipment is capable of vast quantity production, with accurate heat treating under rigid control.

Because of the "E's" with which Tube Turns has handled many forging assignments, it is possible for us to suggest forgings for uses where, formerly, they would have been out of the question. Write to us about your problem. TUBE TURNS (Inc.), Dept. MA-2, Louisville 1, Kentucky.

TUBE TURNS *Forgings for Industry*


METHODS
AND PROCESSES
MELTING and CASTING
Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

Heat Treatment of Cast Structures

Condensed from "Foundry Trade Journal"

Various heat-treatments are used, without hot or cold work, to produce effects both on micro-structure and mechanical properties of two grades of carbon steel castings. A hypereutectoid high silicon steel and a medium carbon steel, both made in acid electric furnaces by the duplex process of continuous pouring, are used for the production of small castings weighing about 50 lbs.

A typical analysis of hypoeutectoid steel was 0.38 to 0.43 C, 0.25 to 0.50 Si, 0.75 to 0.85 Mn, and less than 0.05% S and P. In the as-cast state these steels consist of large, coarsely angular ferrite areas in a matrix of coarse pearlite. A macroetch may reveal columnar dendrites running from the cooling edge for an appreciable distance before a more randon orientation occurs.

Where two sets of opposing dendrites meet, there may be a very definite line of weakness. The degree to which this heterogeneity affects the subsequent heat-treatment depends upon the cleanliness and purity of the steel and also upon the time and temperature of the subsequent operations.

A single normalizing treatment of about 3 hr. at 940 C. (1720 F.) followed by air cooling, will refine the cast structure and will improve the mechanical properties very considerably. Even the shortest anneal (15 min. soak at 880 C. or 1620 F. improves shock resistance remarkably. The higher temperature (950 C. or 1740 F.) is to be preferred for the most satisfactory all-around annealed properties.

Improvement by Heat Treating

Substantial further improvements in strength, without sacrificing shock resistance or ductility, are attainable by quenching and tempering. It seems possible to divide inclusions into two classes: The relatively small inclusions found in primary ferritic areas that appear to have served as nuclei for the primary iron reach dendrites; and inclusions caused by continuous rejection of impurities to the interdendritic regions, and which will be found in association with primary pearlite.

A typical analysis of hypereutectoid steel is: 1.05 C, 1.00 Si, 0.4 Mn, and less than 0.06% S and P. On cooling to the upper critical point, eutectoid pearlite is formed and hypereutectoid cementite is rejected—in general to the junctions of the original dendrite systems.

Normalizing the casting well above the upper change point will greatly refine the structure, and with slow cooling (1 to 2 C. per min.) will eliminate the boundaries of hypereutectoid cementite, giving a coarse pearlite in which excess cementite is distributed at random.

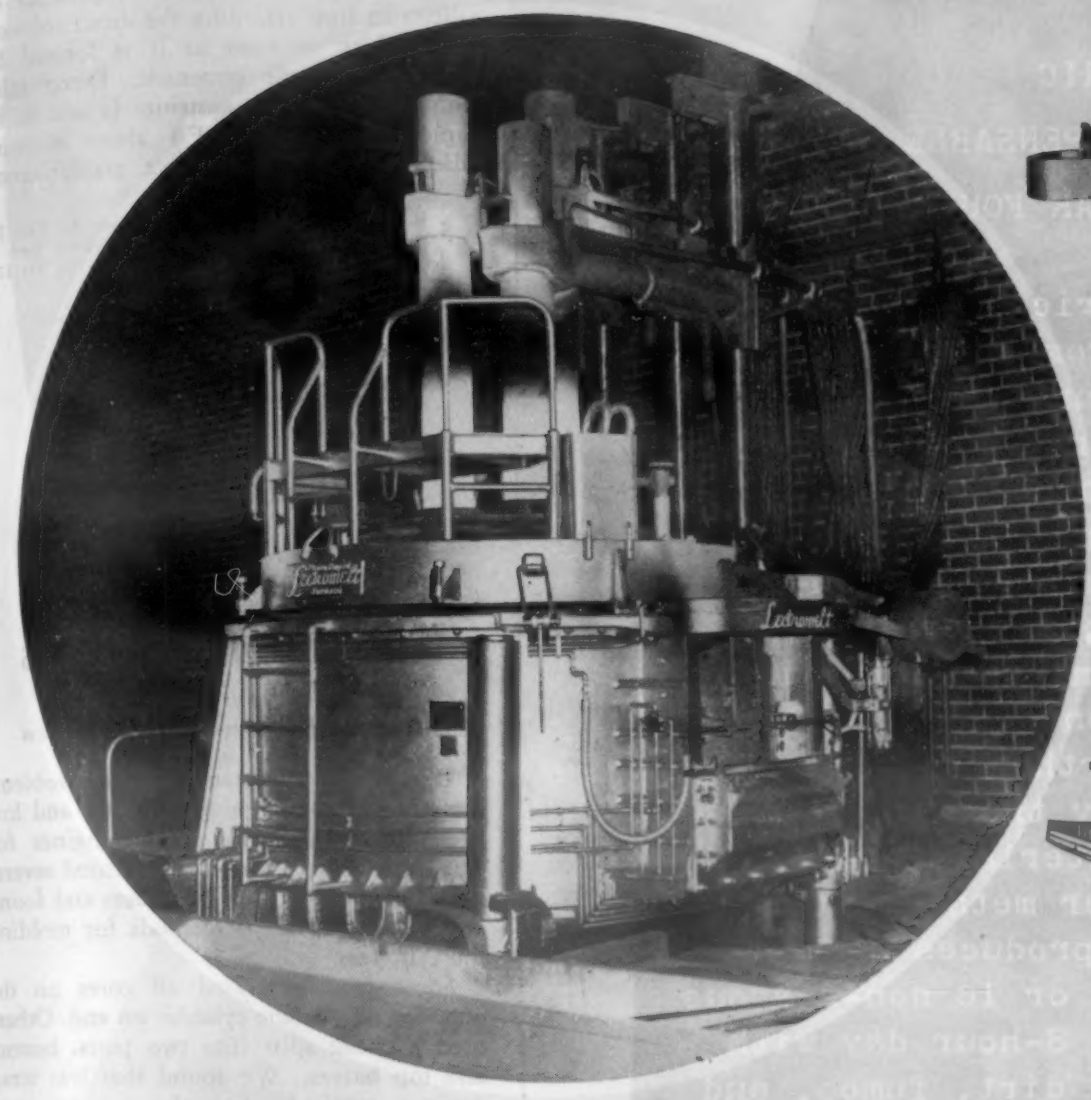
Effect of Normalizing

Normalizing alone does not appreciably improve the mechanical properties. Rapid cooling in an air blast refines the structure, but leaves the hardness and other properties almost identical with the as-cast state. Maximum ductility is obtainable by a spheroidizing anneal at 780 to 800 C. (1440 to 1470 F.) for 3 to 4 hr., followed by slow cooling not exceeding 40 C. (70 F.) per hr.

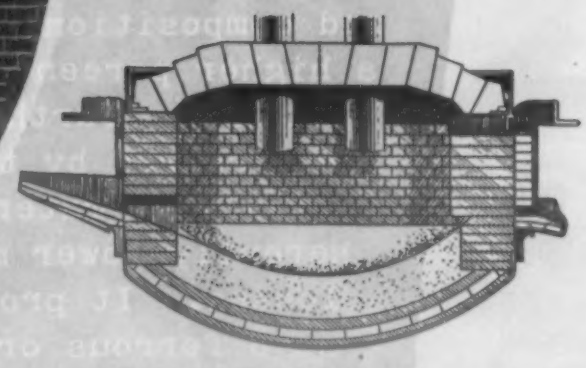
Cementite is stated to be metastable at all temperatures below 1200 C. (2200 F.). Where the concentration of carbon in austenite is low, it will separate out as cementite, even where graphite was previously present, but if high it will separate out as graphite if graphite nuclei are present. A previous 4 to 5 hr. soak well above Acm by removing graphitic nuclei will again cause cementite to be precipitated even with high carbon austenite, but a subsequent very slow cool may cause breakdown of the cementite so formed, even with silicon-free steel.

The upper change point is raised by about 9 C. (16 F.) for each 0.1% Si increase above 1%. This implies a reduction in solubility of cementite or graphite at a given temperature, with a corresponding tendency to retain massive cementite, which is itself unstable.

It is uncertain how far the tendency to retain temper carbon above A. is a function of the actual graphitizing power of Si,



• Lectromelt composite electro-mechanical electrode arm with power operated clamp for gripping the electrodes and conducting the current from the secondary anti-skin effect cables to the electrodes. Another Lectromelt design feature is the electrode clamps, multi-part multi-contact water cooled type (Moore patent).

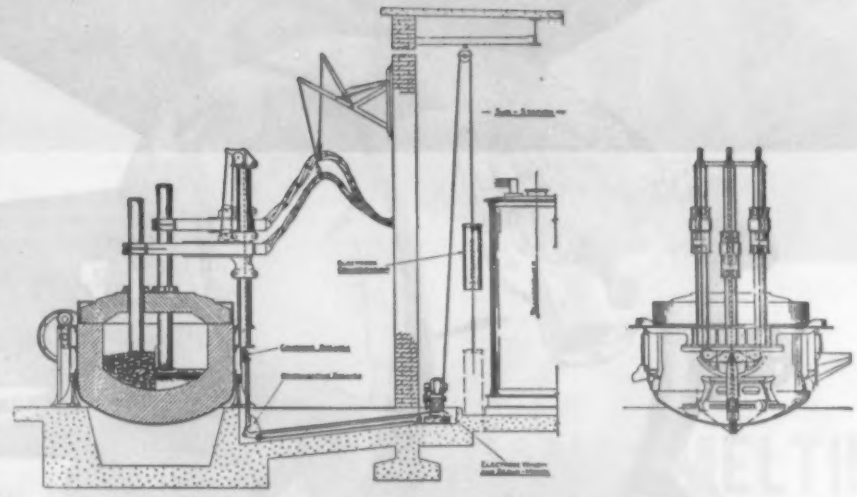


• Lectromelt's patented spheroidal furnace bottom keeps scrap moving down as melting progresses and permits heavy loads and more rapid melting. Lectromelt furnace bottoms are correlated to the angle of furnace tilt so as to insure complete drainage.

Designed for efficiency

★ This recently installed size 12 ton capacity Lectromelt top-charge furnace incorporates the exclusive Lectromelt design features, which assure efficient and economical production of quality steels and irons.

Practical for pouring both large and small heats, Lectromelt top-charge furnaces are available in sizes from 100 tons down to 250 pounds capacity. Details on request.



• The Moore patent, counterbalanced electrode arm winch system is used to operate the "floating" arms with minimum regulating power and to avoid breakage of electrodes. This improved system affords extremely sensitive regulation, so vital in making low carbon metals.

MOORE RAPID

Lectromelt

FURNACES

PITTSBURGH LECTROMELT FURNACE CORPORATION

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WHY A DETROIT ELECTRIC FURNACE IS AN INDISPENSABLE TOOL IN YOUR POSTWAR FOUNDRY

The Detroit Electric Furnace has many advantages which make it the ideal furnace for many foundries. It produces more pounds per man hour. It assures superior metallurgical results through precise control over time, temperature, and composition, resulting in a higher percentage of perfect castings. Further economies are assured by the direct use of salvage materials plus inherently lower metal melting losses. It produces as many as 8 ferrous or 16 non-ferrous heats in one 8-hour day with a minimum of dirt, fumes, and hard work. Detroit Electric Furnaces are available in sizes ranging from the 10 lb. laboratory model to 8,000 lbs. molten metal capacity.

DETROIT ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY • BAY CITY, MICHIGAN

and how far it is due to the presence of silicon in iron retarding the direct solution of graphite as soon as it is formed by breakdown of the cementite. Direct solution of graphite in austenite is said to be rapid at 25 C. (45 F.) above A. with silicon steels so that direct graphitization by silicon is indicated.

—H. T. Angus. *Foundry Trade J.*, Vol. 71, Oct. 19, 1944, pp. 131-135; Nov. 2, 1944, pp. 171-177.

Check Method for Iron Castings

Condensed from "Transactions," American Foundrymen's Association

One of the war manufacturing problems was the making of high, medium and low pressure cylinders for steam engines for war cargo ships. The author visited several foundries making these cylinders and found at least five different methods for molding the cylinders.

Some foundries used all cores on the outside and cast the cylinder on end. Others used a cheek split into two parts, bottom and top halves. We found that less scrap castings resulted when the castings were molded by the cheek method.

In one cheek method foundry the cores were set in the drag, then the bottom half of the cheek was set on the drag over the cores. The top half of the cheek then was placed in position and the remainder of the cores set into the mold. Due to the depth of the mold and to the cores being placed one on top of the other, it was necessary to use chaplets.

Considerable dirt collected in the mold, and as these castings needed to withstand water pressure, dirt elimination was very important. Also, due to the design of the outside portion of the casting, cores had to be used, because of the manner in which the pattern had to be drawn from the cheek.

After visits to various foundries it was decided that, if a 4-part cheek method of molding was used, many cores would be eliminated. Again, by ramming the cheeks in the foundry, using molding sand, production pressure in the overworked coreroom would be relieved. With the 4-cheek method internal cores can be set in place before the mold itself is completed, eliminating chaplets at vital parts.

Equipment used is drag, cheek and core flasks, cope and drag patterns mounted on boards, and 27 core boxes of various types. Castings produced by this method are clean and pass the water test without failure. Time saved in making cylinder castings by this method is so good that this job has proved to be one of the best in the shop when computed on the tons-per-hr. basis.

This method may easily be adapted to other somewhat similar casting problems, especially in cases where a series of built-up cores on both the inside and outside of the mold is required.

FAST POURING IMPROVES UNIFORMITY

THE POURING LADLE shown above, casts six ingots at a time—the fastest casting rate in the brass ingot industry.

As every foundryman knows, when molten brass is ready for pouring, the quicker it is cast the better the casting—and the same is true of ingot.

In addition, here at Michigan Smelting & Refining you get rigid laboratory control, plus fifty years of "know-how", assuring ingot metal that will eliminate for you any possibility of trouble that might come from the metal itself.

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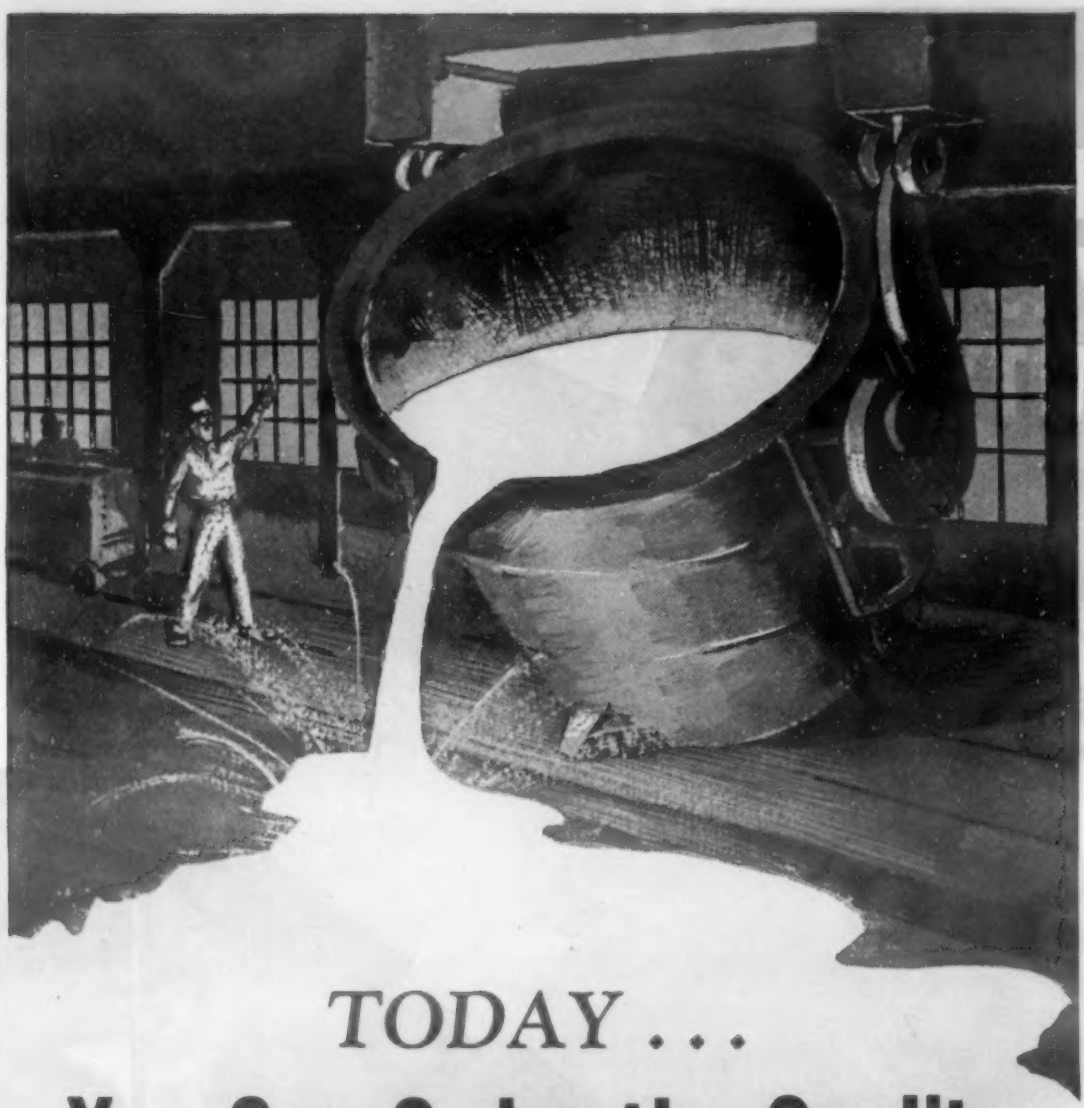

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There are many photographs and diagrams in the article that explain the subject closely enough to allow for duplication elsewhere.

—Robert Hendry. *Trans. Am. Foundrymen's Assn.*, Vol. 52, Dec. 1944, pp. 517-526.

Side Feeding of Steel Castings

Condensed from "Foundry Trade Journal"

A striking feature of steel foundry practice during the past few years has been the development in the side feeding of castings. In Great Britain it has taken the form of the now well-known "whirlgate" head, which depends for its working on the control of the direction of solidification by the temperature gradient.

The "atmospheric" head has been introduced more recently from America. It is usually applied in much the same way as the whirlgate head, but it is "blind" and its height is less. In the ordinary way a "dummy" head often fails, owing to the absence of the atmospheric pressure necessary to force the liquid steel from the head into the casting.

A device in the form of a small core is used to produce a puncture in the first-formed skin at the top of the head, so that atmospheric pressure is admitted to the top surface of the liquid there.

Both heads rely primarily on the directional control of freezing by the temperature gradient that they are admirably designed to produce, but important as that principle is, there are other factors arising from the mechanism of freezing in steel that should not be ignored.

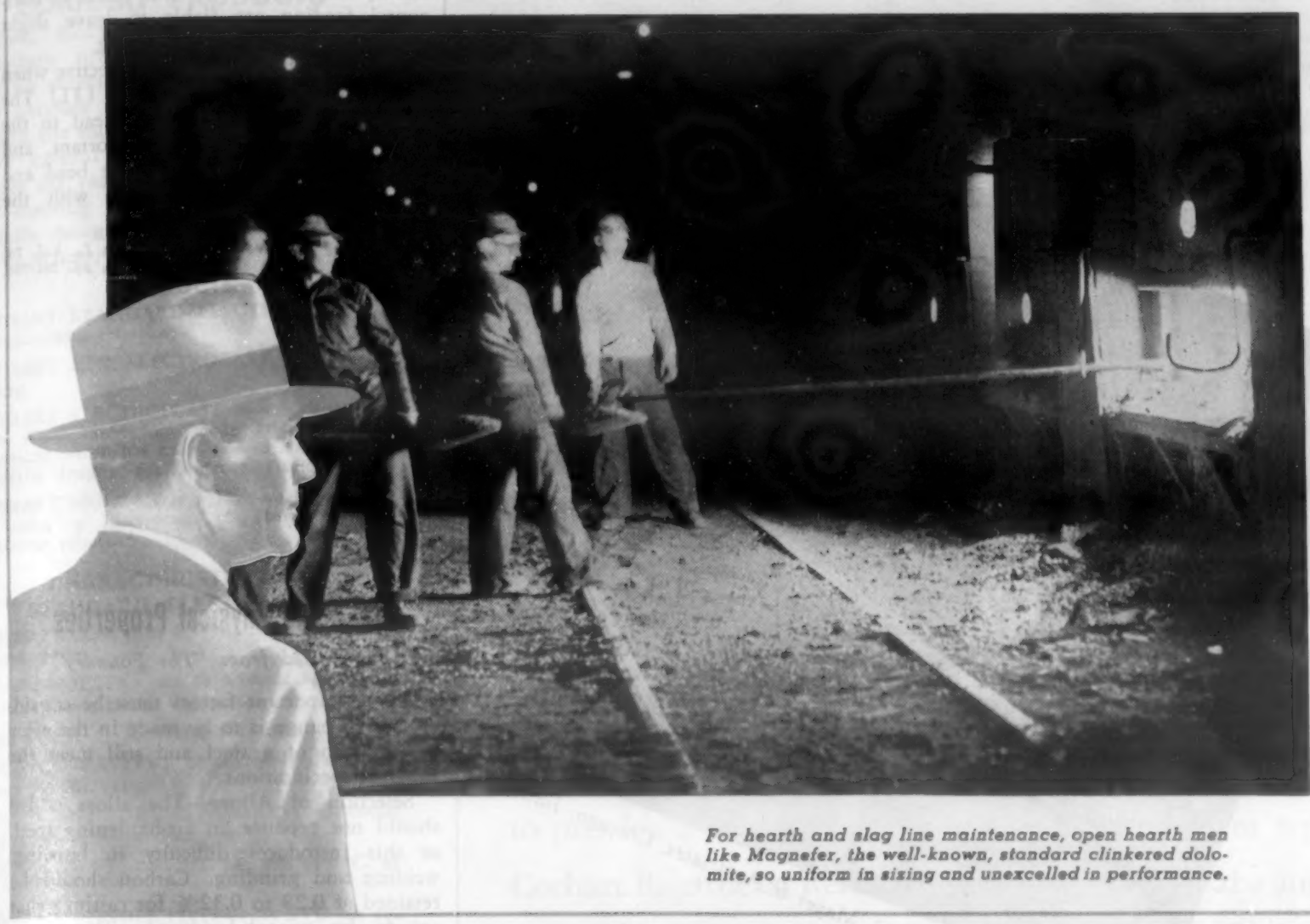
For the present investigation, blocks 4 x 4 x 18 in. were made in four different ways: Cast vertically with a bottom runner and top head, cast horizontally with a whirlgate head at one end, cast vertically through a top head, and cast vertically with a whirlgate head under the bottom.

Conclusions Drawn

The following conclusions were drawn: (1) Atmospheric pressure and not gravity is the effective motive force in the feeding of all castings. (2) Top-running through the head is effective in sections greater than 3 in., particularly when the shape of the mold is favorable. (3) Bottom-running with top heads is satisfactory under the same conditions.

(4) Top heads are not efficient in sections less than 3 in. thick. (5) Top heads are not efficient in horizontal feeding. (6) Side heads give a greater depth of solid wall in horizontal feeding and are, therefore, to be preferred in certain cases. (7) Side heads are effective to considerable horizontal distance from the head.

(8) Side heads applied to the bottom of a casting give the best results in sections under 3 in. thick, and are quite effective



For hearth and slag line maintenance, open hearth men like Magnefer, the well-known, standard clinkered dolomite, so uniform in sizing and unexcelled in performance.

FIRST HELPER FOR LOWER HEARTH MAINTENANCE

HOW can open hearth "delay time" be reduced—now that furnaces are so pushed, month after month, at capacity operation?

The answer lies in the policy of using the best refractories available and in efforts constantly to improve refractory practice.

We supply basic refractories that support such a policy...refractories carefully designed and accurately controlled in manufacture to have desirable physical, chemical and mineralogical properties which enable them to meet severe furnace conditions.

The greatest plus value in Basic Refractories products, however, is that they are sold and serviced by representatives who intimately know steel making. "Basic" Sales Engineers are practical steel men, with years of experience making steel. This experience they supplement with a sound knowledge of basic refractories. Often they are able to offer suggestions which help solve tough problems, and so improve refractory practice—in slag line maintenance, in bottom repair, in new hearth construction.

So think of the "Basic" Sales Engineer as your "First Helper" for lower hearth maintenance costs. Use his knowledge and experience freely, to insure that the dependable basic refractories you get from him are yielding the best possible results.

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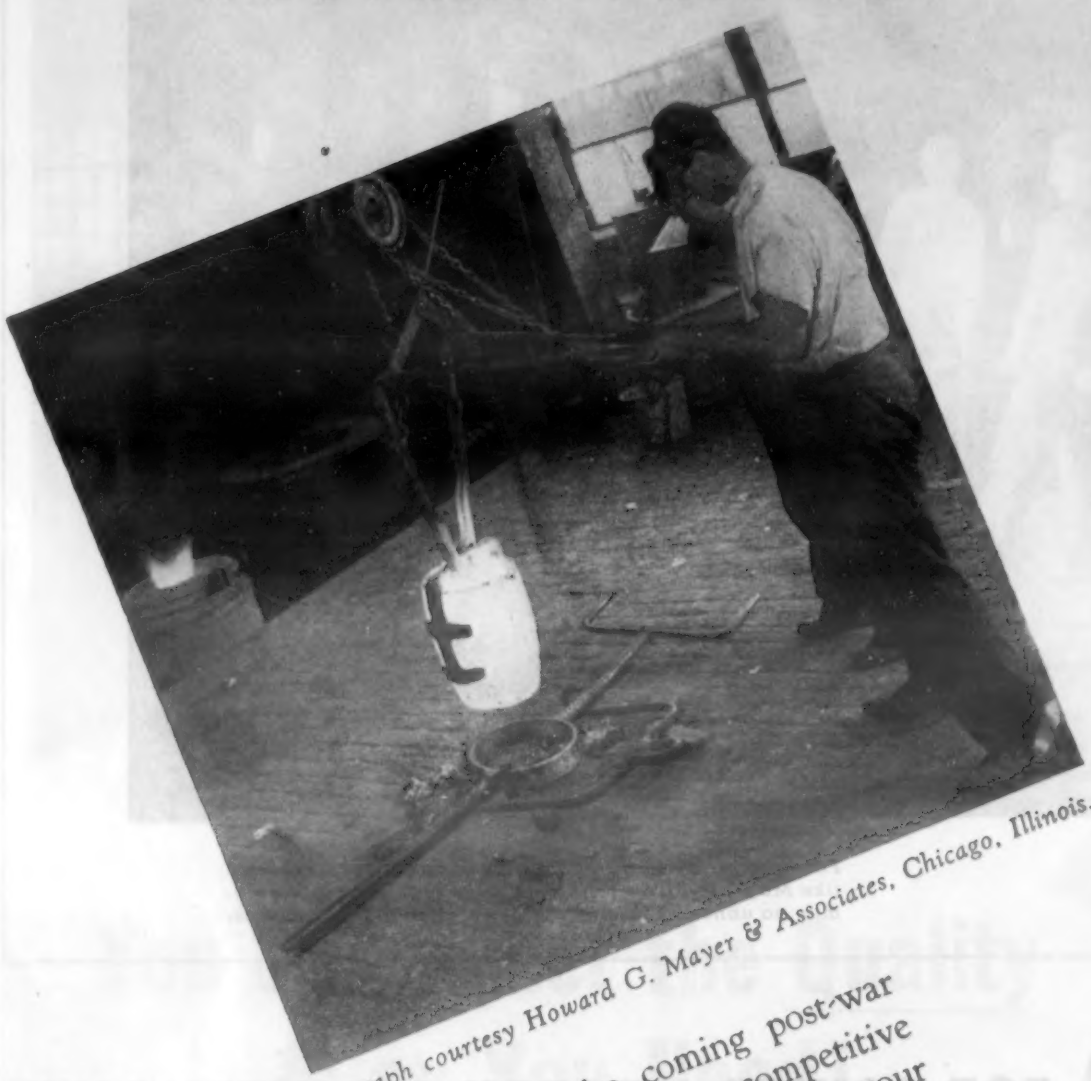


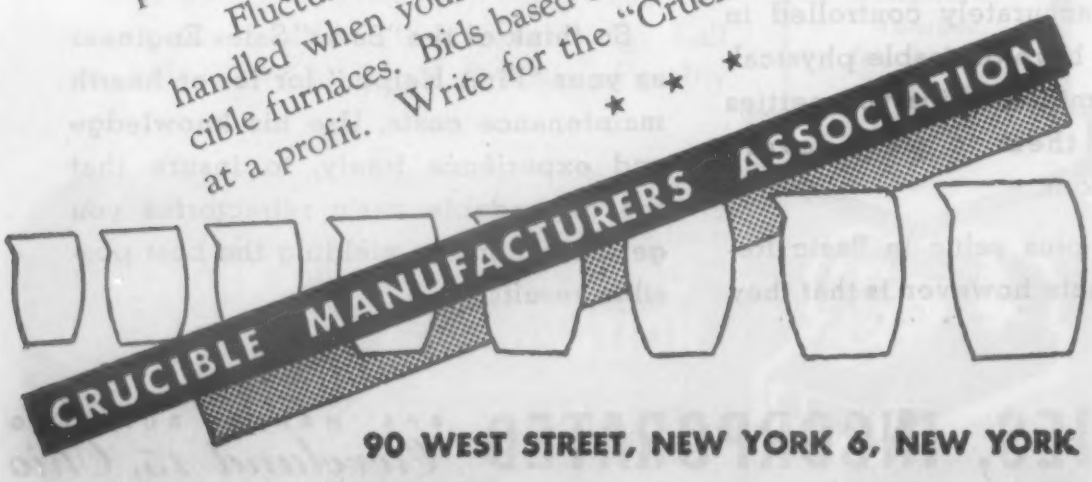
Photograph courtesy Howard G. Mayer & Associates, Chicago, Illinois.

Many non-ferrous foundries in the coming post-war period will return to job contracts gotten by competitive bids. Your competitive position will be determined by your costs. Lower costs will depend first on low investment as with Crucible furnace equipment.

Other economies of Crucible furnaces result from flexibility, adaptability, low operating costs and freedom from stand-by charges. Where Crucible melted metal is poured casting rejections are minimum.

Fluctuation in orders and alloy specifications are easily handled when your foundry is equipped with modern crucible furnaces. Bids based on lower costs will land contracts at a profit. Write for the "Crucible Melters' Handbook."

★ ★ ★



90 WEST STREET, NEW YORK 6, NEW YORK

for thicker sections when applied so that the head keeps the bottom of the casting hot by conduction. (9) Side heads in horizontal feeding are liable to leave slight axial unsoundness in the casting.

(10) Side heads are not so effective when applied to the top of a casting. (11) The conduction of heat from the head to the casting during freezing is important, and is controlled by the size of the head and the design of the connection with the casting.

—B. Gray. *Foundry Trade J.*, Vol. 74, Nov. 9, 1944, pp. 201-204.

Retaining Physical Properties

Condensed from "The Foundry"

Three important factors must be considered if a change is to be made in the alloy composition of a steel and still meet the physical specifications:

Selection of Alloys—The alloys added should not produce an air-hardening steel, as this introduces difficulty in burning, welding and grinding. Carbon should be retained at 0.28 to 0.32% for castings that are to be quench-hardened. The alloys should make the casting strong and tough but not brittle after the quench and draw. The amount of alloys employed should be retained at a minimum in compliance with the conservation program. The writer was especially interested in the production of satisfactory castings with a minimum molybdenum content.

Correct Deoxidants and Deoxidization—WPB requirements limit the amount of aluminum for deoxidization to 2½ lbs. per ton of steel. This aluminum must be added so that it does not come into contact with the slag. If the aluminum comes in contact with the slag, incomplete deoxidization and undesirable inclusions in the steel are probable consequences.

Heat Treatment—The quenching of 4C2 and 4C3 castings should be drastic enough to produce a hardness over 300 Brinell but still not produce quench cracks. The author prefers to normalize his castings from 1700 F. prior to water quenching from 1600 F. and drawing to the required hardness.

Nine 4000-lb. heats were made in which varying deoxidization practice and alloy compositions were used. In these heats the carbon content was varied from 0.28 to 0.36%, and the chromium varied from 0.02 to 0.32%. The molybdenum varied from 0.08 to 0.26% in comparison with the 0.36% molybdenum normally used in this steel.

The deoxidization practice was varied using combinations of calcium-manganese-silicon, aluminum, ferrotitanium and Borosil. The test, which was deoxidized with calcium-manganese-silicon and ferrotitan-

A FEW FACTS ABOUT CORHART PRODUCTS

Corhart Electrocast Refractories are high-duty products manufactured by melting selected and controlled refractory batches in electric furnaces, and casting the molten material into molds. After careful annealing, the finished shapes are ready for shipment. Dense, high-melting refractories, they are especially designed for resistance to corrosive action.

PRODUCTS

CORHART STANDARD ELECTROCAST is a high-aluminous refractory.

CORHART ZED ELECTROCAST is Zirconia-bearing.

CORHART ELECTROPLAST is a high-temperature plastic refractory made from Standard Electrocast which has been ground and crushed. Especially designed for ramming. Furnished dry.

CORHART MORTAR is a high-quality cement for laying up Electrocast, clay brick, or any aluminous refractory.

CHARACTERISTICS OF STANDARD ELECTROCAST

POROSITY: Less than 0.5%—therefore virtually no absorption.

FUSION POINT: Cone 38 without any appreciable softening below that point.

HARDNESS: 8, Mineralogist's scale.

SPECIFIC GRAVITY: Blocks weigh approximately 183 lbs. per cu. ft.

COEFFICIENT OF EXPANSION: 0.000006 between room temperature and 900° C.

SPECIFIC HEAT: 0.25 cal. per gm. per °C. at 980° C.

THERMAL CONDUCTIVITY: 25 BTU per sq. ft. per hour for gradient of 1°F. per inch.

COMPOSITION: Standard Electrocast is of an aluminous crystalline nature.

CORROSION: Because of low porosity and inherent chemical make-up, Corhart products are highly resistant to corrosive action.

APPLICATIONS

Most heat processes present spots where a better refractory material is needed in order to provide a balanced unit and reduce the expense of repeated repairs. It is for such places of severe service that we invite inquiries regarding Corhart Products as the fortifying agents to provide the refractory "balance" desired.

The following is a partial list of applications for which Corhart Products are suggested:

ELECTROLYTIC CELLS — for production of Magnesium and other light metals.

SILICATE OF SODA FURNACES — sidewalls, bottoms, and breastwalls.

HEARTHS AND SMELTERS — for non-ferrous metals.

ALKALI AND BORAX MELTING FURNACES — fast-eroding portions.

GLASS FURNACES — the entire installation of flux walls and bottoms, breastwalls, ports, tuck-stones, forehearths, recuperators, etc.

RECUPERATORS—tile, headers, separators, etc.

ENAMEL FRIT FURNACES — flux walls and bottom.

BRASS FURNACES — metal contact lining.

ELECTRIC FURNACES — linings for rocking type, and rammed linings of Electroplast for this and other types.

BOILERS — clinker line.

STOCK SHAPES AND SPECIALS

Standard and Zed Electrocast are made in stock shapes and in many special shapes. The weight of individual pieces may run to 3500 pounds.

IF YOU NEED

A BETTER REFRACTORY—

● Corhart Electrocast Refractories are high-duty products which have proved considerably more effective than conventional refractories in certain severe services. If your processes contain spots where a better refractory is needed to provide a balanced unit and to reduce frequent repairs, Corhart Electrocast Refractories may possibly be the answer. The brief outline at the left gives some of the basic facts about our products. Further information will be gladly sent you on request.

Corhart Refractories Company, *Incorporated,* Sixteenth and Lee Streets, Louisville 10, Kentucky.

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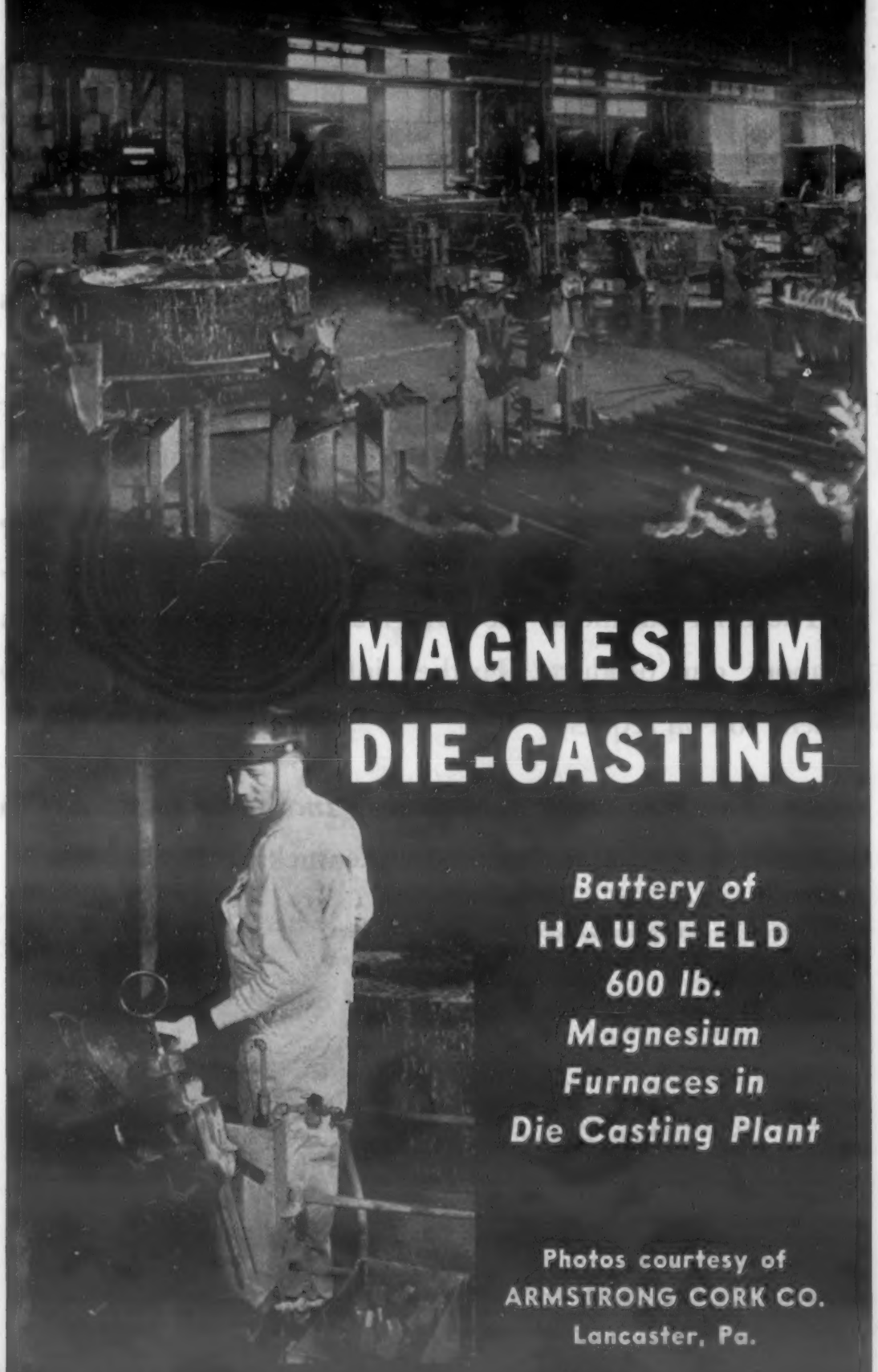
QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

HAUSFELD FURNACES



MAGNESIUM DIE-CASTING

Battery of HAUSFELD 600 lb. Magnesium Furnaces in Die Casting Plant

Photos courtesy of ARMSTRONG CORK CO. Lancaster, Pa.

The Campbell-Hausfeld Co.

200-220 MOORE ST. HARRISON, OHIO

ium, produced porous castings. Aluminum with other deoxidizers was used for all the other heats except one, which was deoxidized with calcium-manganese silicon and Borosil. No porosity was reported for any heat except the one noted.

The heat deoxidized with calcium-manganese silicon and Borosil, which contained 0.36 C, 1.45 Mn, 0.09 Mo, 0.11 Cr (residual) and 0.0006% B, was the leanest alloy composition which would still meet the requirements of the 4C3 specification.

—T. D. West. *Foundry*, Vol. 72, Dec. 1944, pp. 93, 228, 230, 232.

Standardization of Blast Furnaces

Condensed from "Stahl und Eisen"

The German metallurgical industry has accepted a standard blast furnace that combines all modern experiences with respect to design and operation, is simpler, and means a great saving in building materials. The furnace has a useful content of 750 cu. m. (26,500 cu. ft.), and corresponds to the frequently used 1000 (metric) ton (1102 short ton) furnaces.

The total height from floor to top is 29 m. (95 ft.), hearth diameter is 6 m. (19.7 ft.). The daily capacity is about 700 to 800 tons (770 to 880 short tons) of pig iron with rich iron ores and 350 to 400 tons (386 to 440 short tons) with low grade iron ore; flue dust 3 to 5%, the number of tuyeres 12.

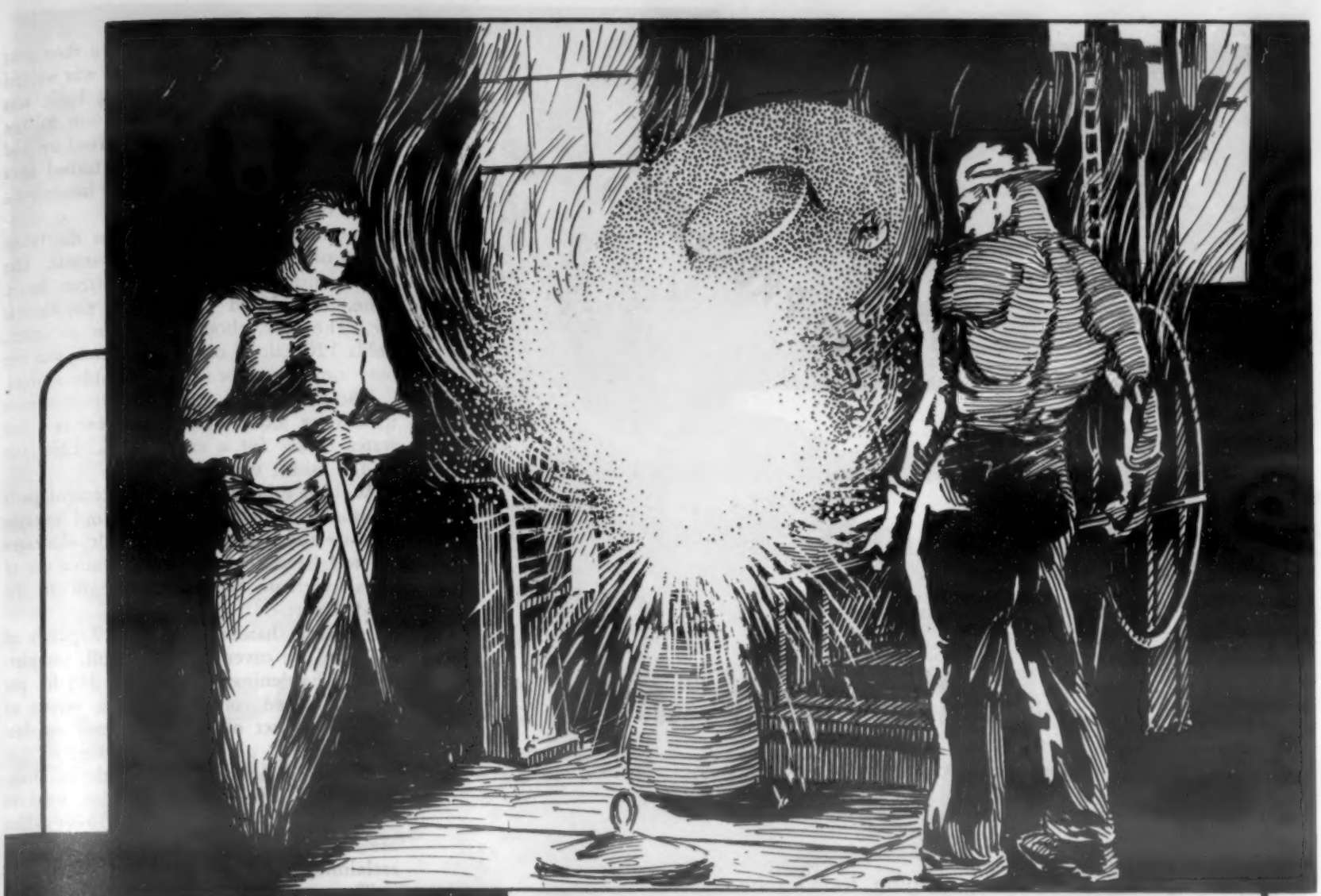
The furnace is kept together by a welded sheet mantle of 50 mm. (2 in.) at the bosh, 40 mm. (1½ in.) at the tuyeres and 25 (⅞ in.) around the stack. The skip hoist is the usual, but either drop buckets or tilting buckets are used; the former drops large ore and coke charges at once. The latter is for smaller charges, but for better distribution in the furnace, a rotating top is provided.

The hoist with tilting buckets is given preference, although many operators say the drop bucket system requires less coke and gives less dust. The hearth is made of tamped carbon mass. The lining of the stack has 500-mm. (20 in.) thickness; cooling boxes and ribs are built into the lining.

The standard furnace is cooled only as much as long life without increase of coke charge requires. The lower part around the hearth is cooled with water, the stack by the cooling boxes, which have a total cooling surface of about 41 sq. m. (441 sq. ft.).

The weight of the new furnace is about 1200 tons (1320 short tons), 900 tons (990 short tons) lower than other modern blast furnaces. Some details as hot blast orifices, arrangement of tuyeres, and reinforcing of lower parts are subject to changes according to local conditions.

—G. Bulle. *Stahl u. Eisen*, Vol. 64, May 4, 1944, pp. 285-290.



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RAMMING MIXES—P. B. Sillimanite No. 217 Ajax Ramming Mix and Tayco No. 219 Ajax Mix will give long life and increased furnace production, when used for either the crucible section or the slot or secondary block in Ajax-Wyatt induction furnaces melting cartridge brass and high copper alloys. These mixes are designed for low permeability — high refractoriness — good ramming properties and high density.

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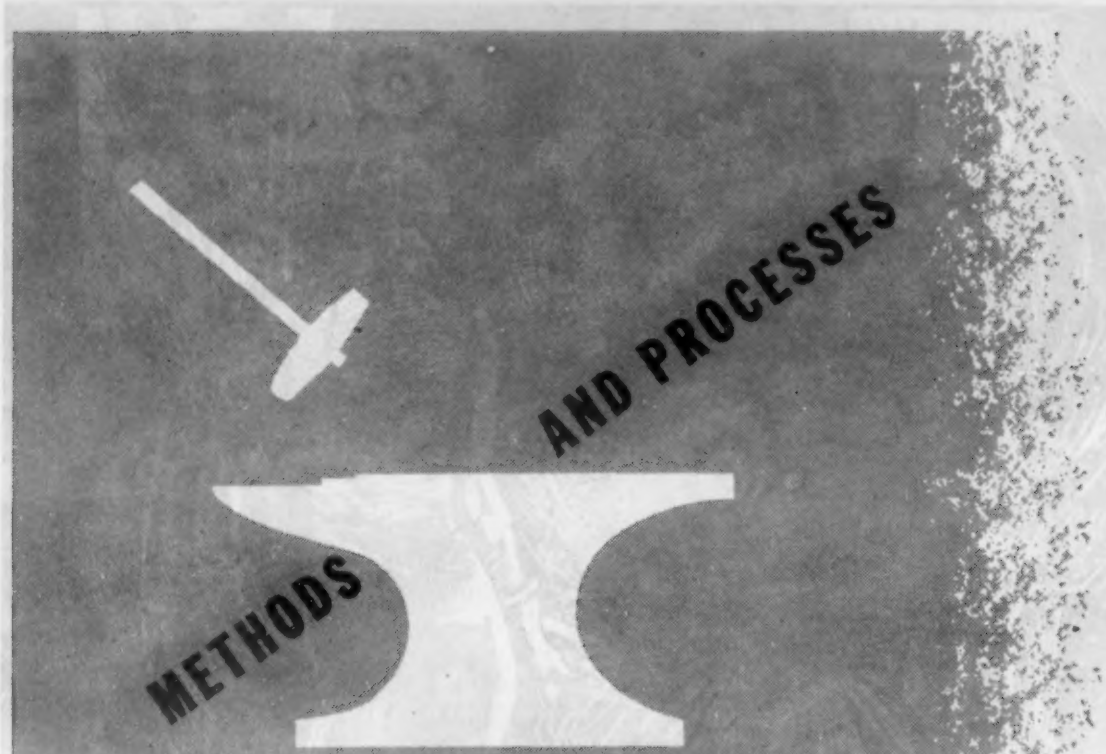


FABRICATION and TREATMENT

Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.

Steel Mill Maintenance Welding

Condensed from "The Welding Journal"

The functions of a welding department in a steel mill are not uniform. In one mill the welding department may perform only the minimum amount of work to keep the mill equipment in good condition; in others duties may expand during wartime in fabricating some parts or making the mill self-sufficient in providing all repairs, replacements and original construction needs. At the Yorkville plant of Wheeling Steel Corp. a crew of eight welders and two helpers do all repairs, replacements and new fabrication.

An interesting job by this department was the construction by low temperature brazing of copper conductor rolls for an electrolytic tinning mill. This roll is made of an outer shell, two web disks, two heads and a shaft.

Trouble was encountered in drilling holes in the shaft. This was accomplished by grinding the drill off center and using carbon oil lubricant. The two webs were then roughed to size and the center hole bored 0.001 in. smaller than the shaft diam.

To insure sufficient heat at the point of brazing, two natural gas and compressed air burners were played on the shaft until the baffle became red. Burners were then shut off and ⅓ of the circumference was welded with No. 12 tips. The second baffle was brazed the same way, using 3/16-in. Sil-Fos rod. The shaft assembly was turned up and the outside rim of the baffles turned to a diam. 0.003 in. larger than the inside bore of the outer shell.

Another construction job was the fabrication of an oil reclaiming apparatus. The oil warming tank was made from ⅛-in. plate, formed and welded with the electric arc. The tank, about 3 ft. 7 in. in diam., holds 120 gal. of oil. The purifier was the only unit purchased from outside sources.

The bulk of the original fabrication runs to simpler jobs. Typical of these is a hot water heater for a caustic tank, bonderite sludge tanks, etc.

Welded fabrication of replacement parts is usually a matter of cutting out sections of plate and joining them. Lately, shortages of steel have dictated a conservative use of metal without sacrificing strength in the welded part.

In flame hardening rolls, 12 passes of the 4-in. tip cover the entire roll, completing the hardening operation in 2½ hr. per roll. Finished rolls made at a saving of $600 for a set of two performed satisfactorily.

One reclamation operation is the building-up of worn bronze side guides, used in tandem and finish mill rolling. These guides are repaired by welding. The total cost of reclaiming a guide is about $1.18.

The number and variety of maintenance jobs in a steel mill is limitless. Work formerly done by riveting can be done by welding. With a small stock of materials, including plates, structural shapes, and pipe, the maintenance department is prepared to cope with almost any problem.

—E. W. Gruber. *Welding J.*, Vol. 23, Nov. 1944, pp. 1031-1040.

Plastic Finishing of Metal Products

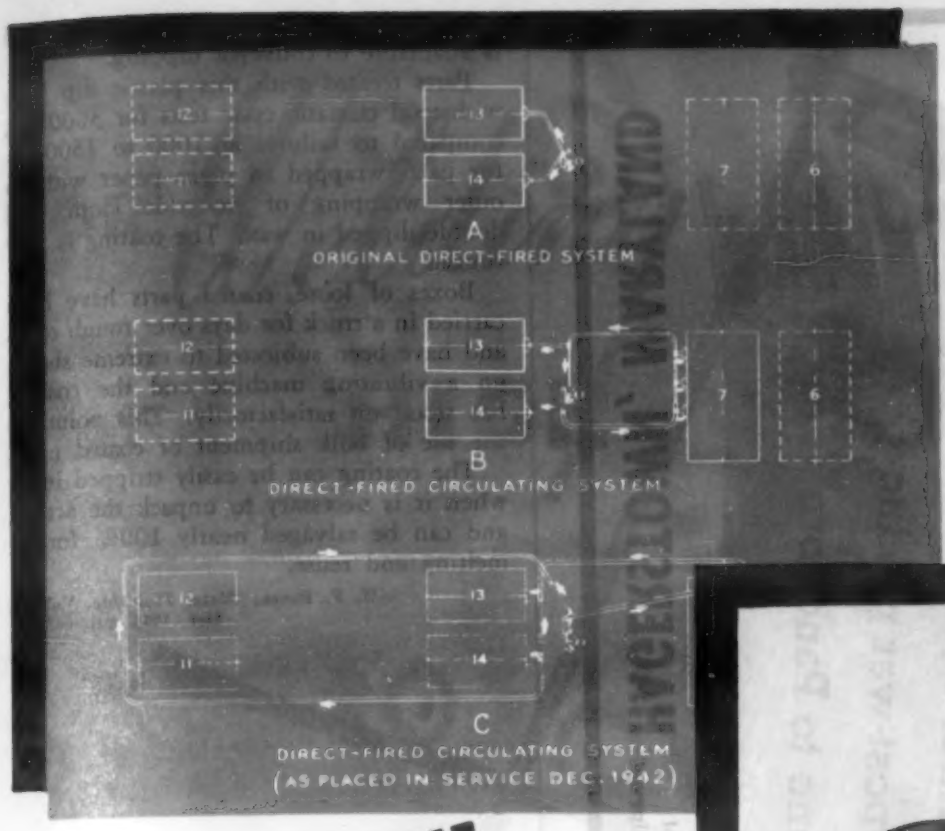
Condensed from "Metal Finishing"

The successful use of a plastic coating on metal parts indicates the possibility of the widespread use of this material in this type of application.

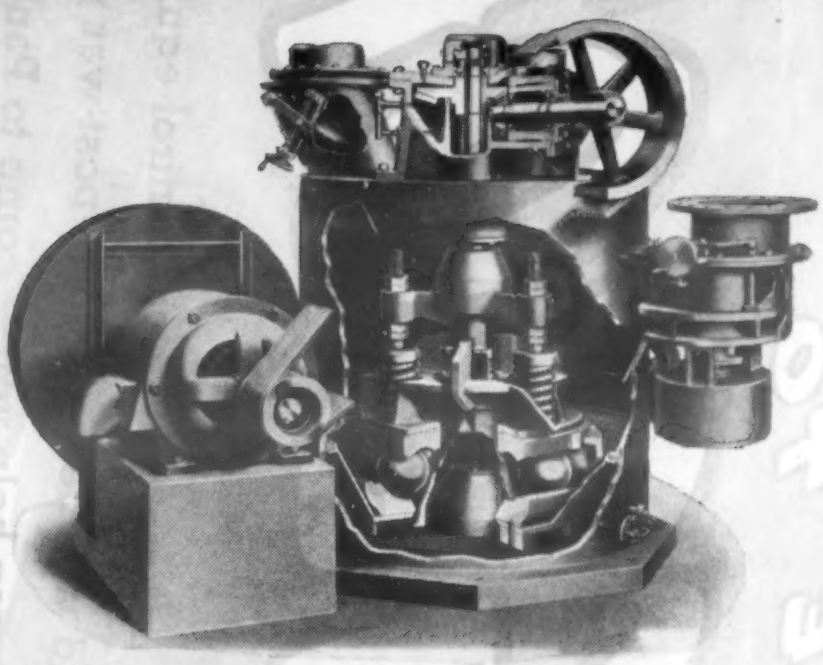
So far, plastic coatings have been used largely for packaging. The formula of a compound used for this purpose is 25% ethyl cellulose, 25% resin and plasticizer, and 50% mineral oil and wax, with 1% stabilizer or inhibitor sometimes added to give high-temperature stability. The coating is shipped in blocks and is melted in a pot kept at a temperature of 350 to 375 F.

The part to be coated is immersed in the molten plastic for about 2 sec., pulled out, allowed to drip into the pot, and then dipped into cold water to harden the coating rapidly. A coating thickness of about 0.1 in. is obtained.

The coating is a temporary covering which serves completely to protect a part from corrosion and abrasion during shipping. Labor saving over hand wrapping of



SAVINGS START HERE



Cutaway view of B&W Type B Pulverizer

with the B&W Direct-Firing Pulverized-Coal Circulating System

Substantial savings in installation, operating, and maintenance costs over other methods of firing metallurgical furnaces are made possible by the B&W Direct-Firing Pulverized-Coal Circulating System. A single pipe looped overhead and around several furnaces supplies air-borne pulverized coal of proper fineness to as many burners as are required for the service. Automatic control provides the same flexibility as obtained with oil or gas. With this method of firing, only ONE pulverizer is needed. It can be set where convenient; saving floor space and eliminating interference with product handling at the furnaces.

With this system you save fuel, reduce heating cycle time, and increase production. These savings begin at the heart of the system—the B&W Type B Pulverizer. Fuel distribution and capacity of the system, whether for single or multiple furnace operations, is assured because the Type B Pulverizer is built to stay on the job and to pulverize its rated capacity in coal to the fineness necessary for the specific requirements of each installation. This pulverizer is of the same type as that widely used for firing boilers and cement kilns, where sustained fineness and capacity of product and continuous low-cost operation are governing factors. They assure the same dependable service in this simplified method of firing metallurgical furnaces.

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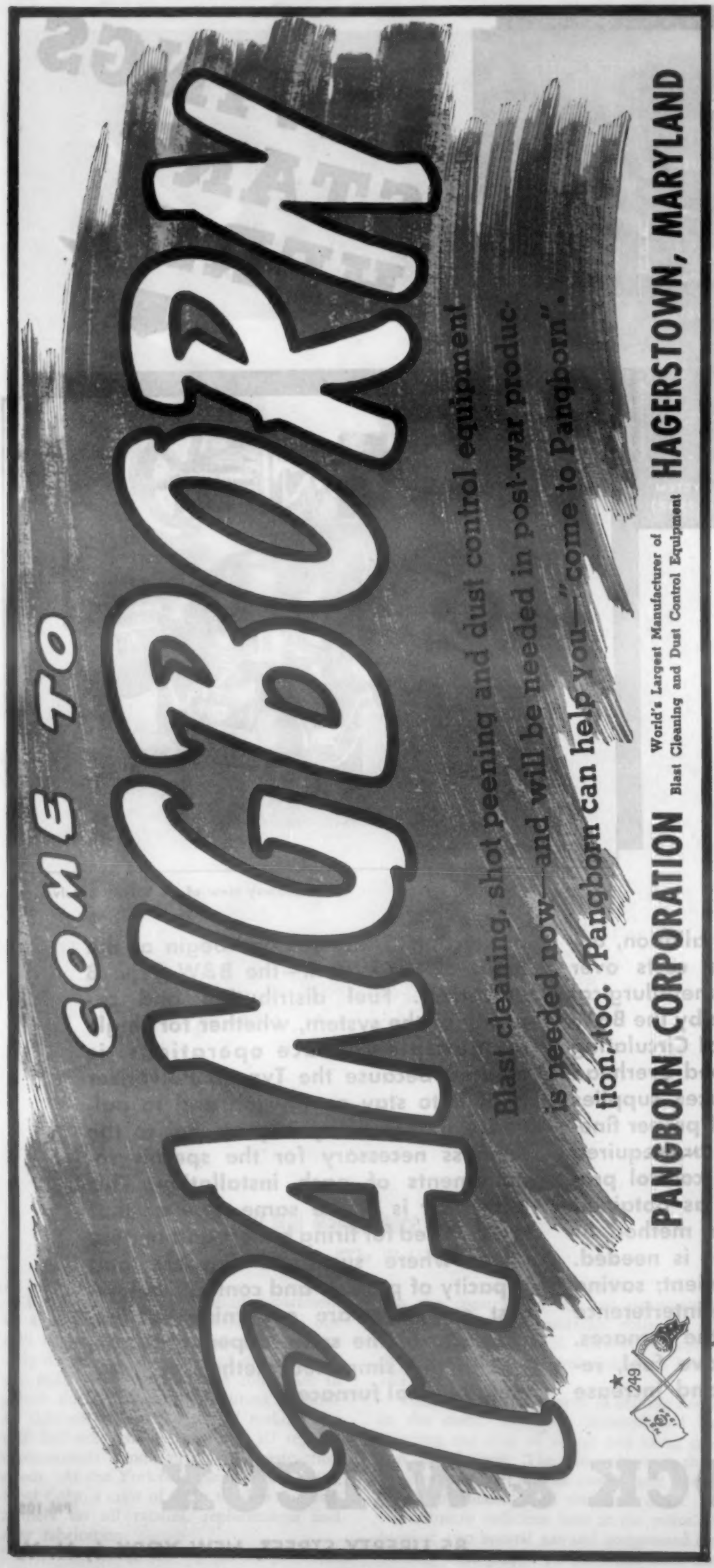
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parts is as high as 90 to 95%. The method is adaptable to conveyor dipping.

Parts treated with this plastic dip have withstood climatic cycle tests for 3000 hr., compared to failures at 1000 to 1500 hr. for parts wrapped in plain paper with an outer wrapping of no-oxide cloth, and double dipped in wax. The coating is very rugged.

Boxes of loose, coated parts have been carried in a truck for days over rough roads and have been subjected to extreme shocks on a vibrating machine and the coating has stood up satisfactorily. This points to the use of bulk shipment of coated parts.

The coating can be easily stripped intact when it is necessary to unpack the article, and can be salvaged nearly 100% for remelting and reuse.

—H. F. Reves. *Metal Finishing*, Vol. 42, Oct. 1944, pp. 647-649.

Diffused Chromium Coatings

Condensed from "Stahl und Eisen"

A corrosion-resisting surface on steel can be produced by diffusing chromium into the steel surface at temperatures of 1000 to 1200 C. (1830 to 2290 F.). A diffusion layer of 0.1-mm. thickness requires about 0.2 kg. per sq. mm. In order to obtain a good chromium layer, uniform contact of the chromium-bearing agent with the whole surface of the material is necessary. The halogen salts of chromium, which react with iron at higher temperatures under formation of iron halides, have been found to be especially suited.

Chromation by chromium salts can take place by applying either the liquid or gaseous phase. In the former case, the salt bath process, any desired bath concentration can be obtained by adding the chlorides of the earth alkalies which do not disturb the exchange reaction between chromium and iron.

The most applied salt is chromous chloride ($CrCl_2$), a colorless, highly hygroscopic salt melting at 820 C. (1500 F.), which has at 1100 C. (2000 F.) a vapor pressure of about 25 mm. If chromous chloride is diluted with the chlorides of other metals, *e.g.* barium, calcium or magnesium, the chromous chloride is still stable in the salt melt at 1200 C. (2290 F.).

While the concentration of $CrCl_2$ in the gaseous state is given by temperature and partial pressure and can be controlled in only very narrow limits, there exists in the molten state the possibility of adjusting to any desired concentration up to 50%; this is the greatest advantage of the salt bath process. The most favorable conditions exist at about 20% $CrCl_2$ in the salt bath.

The chromated layer can be increased by different alloying elements in the basic material and by changing the bath composition, either by changing the concentration ratio $CrCl_2/CrCl_3$ or by the addition of vanadous chloride. The gaseous process has to be carried out in a closed muffle of austenitic heat-resisting steel under pressure.

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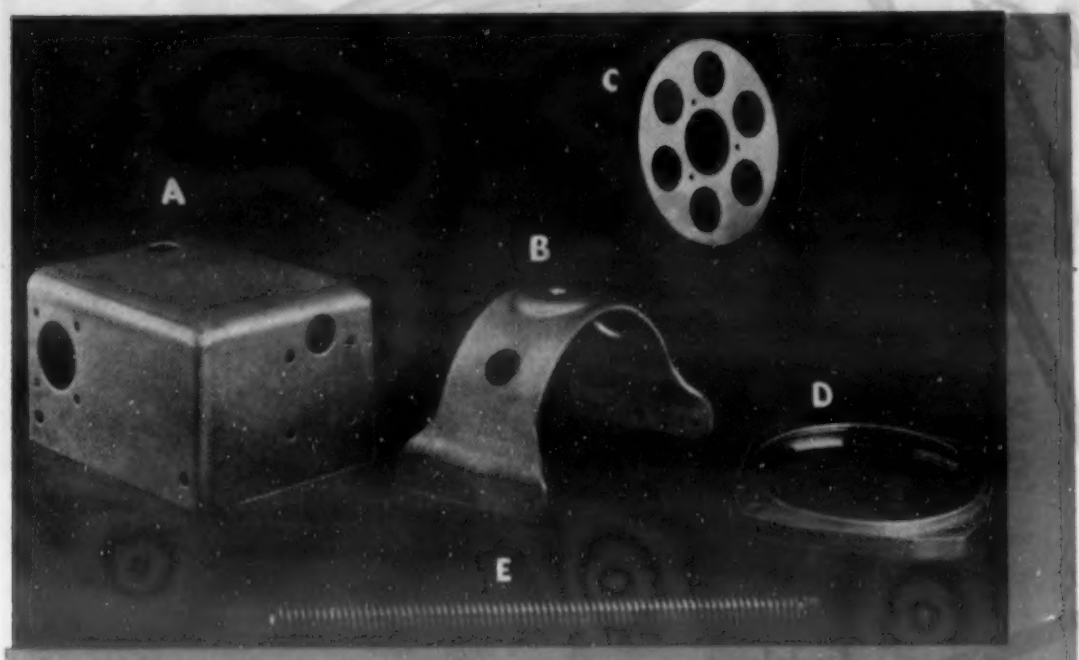

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Welded parts can be readily chromated, if an austenitic corrosion-resistant welding wire has been used for the weld (18-8 steel).

An important economical point of view in favor of diffusion chromation is that chromium alloy steels need ferro-chromium for their production and depend, therefore, on the availability of this material. This becomes entirely unnecessary by the application of the diffusion process as chromium chloride is produced directly from the chromium ores.

—H. Bennek, W. Koch & W. Tofaute. *Stahl u. Eisen*, Vol. 64, Apr. 27, 1944, pp. 265-270.

Case Hardening by Megacycle Induction Heating

Condensed from Transactions of the Electrochemical Society

This paper is concerned largely with the results obtained at megacycle frequencies of 2 to 15 million cycles per sec. Low frequency hardening, in which 30 sec. or more heating is required, and in which an external coolant is used, results in a variable case depth and usually in alteration of the properties of the pretreated core.

With the megacycle method, with high power imput, the heat is generated rapidly, in 1 sec. or less, in a thin surface layer. The quench is achieved by the rapid flow of heat inward to the cold core. The case depth is determined entirely by the heating conditions, and not by the geometry of the part. Any case depth from 0.003 to 0.060 in. can be had at the will of the operator.

Heating and quenching is so rapid that no scale is formed in air. Distortion of parts is negligible, since the case depth is uniform, resulting in uniform stress. In any case, the stress is small because the case is thin.

Costs are dependent on the efficiency of the frequency conversion apparatus, on the accuracy of control, and on the case depth. In one example, the power cost for hardening an area of 50 sq. in. to a depth of 0.02 in. was one cent. It is desirable, for economy of operation, to restrict the case depth to only slightly more than the allowable wear of the part.

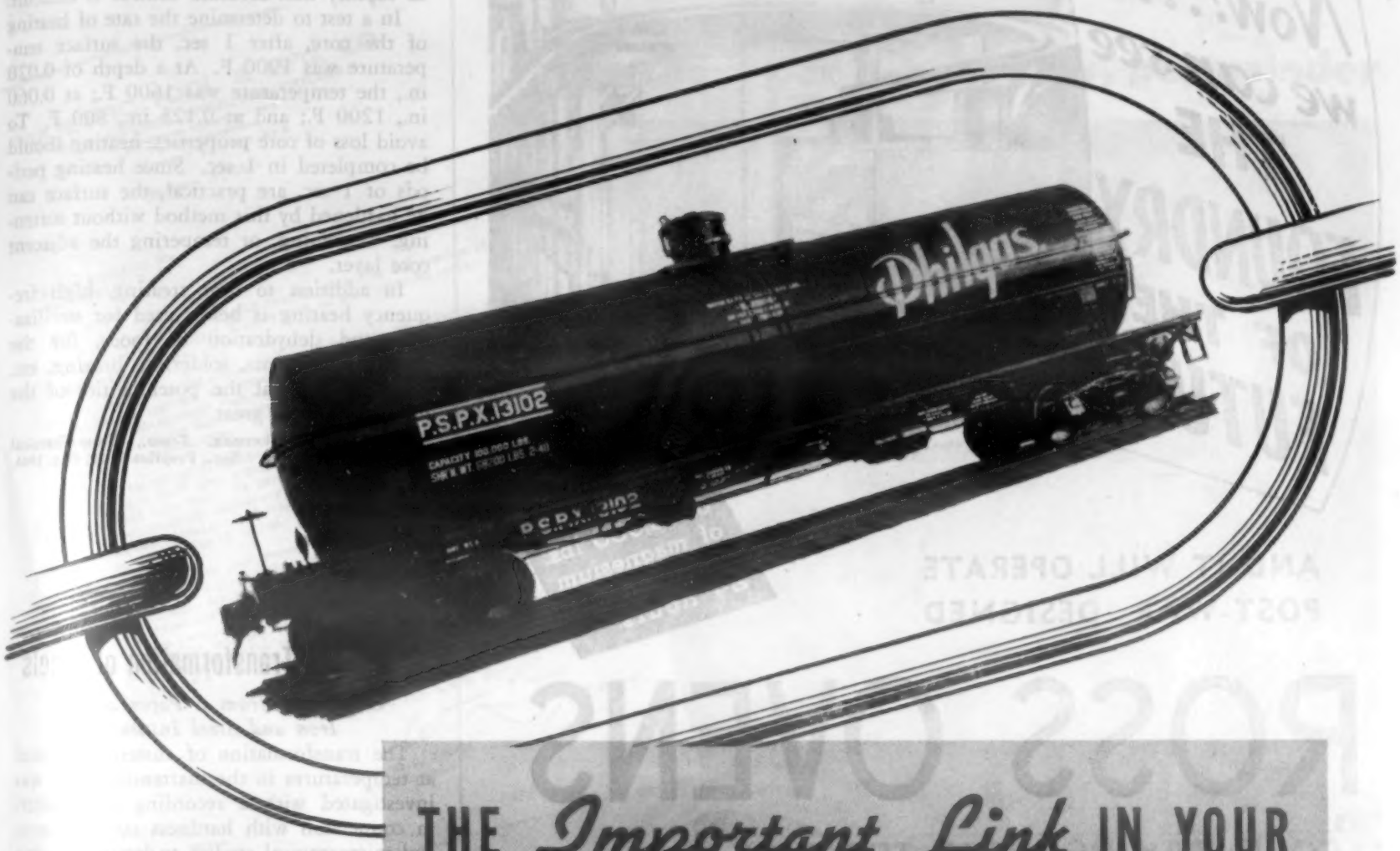
Satisfactory results are obtained in practice with energy imputs between 10 and 15 kw. per sq. in.

Practical applications of megacycle induction hardening have been made on various types of surfaces and several types of steel. The hardening of gear teeth, bearing surfaces of partially hollow shafts, and flat plates is described.

A navy sextant gear, 3-in. outside diam. by 0.02-in. thick, made of SAE 1090 steel, was surface heated to 1600 F. with 12 kw. of energy in 0.7 sec. and self-quenched. This treatment hardened the teeth to a depth of 0.020-in. to a hardness of 63 Rockwell C. Core hardness was 20 Rockwell C.

Tests performed to determine the relation between case depth and time of heat treat-

ADEQUATE TRANSPORTATION



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ment show this relation to be approximately linear up to 1 sec. heating time. With longer heating times the case depth increases so rapidly that accurate control is difficult.

In a test to determine the rate of heating of the core, after 1 sec. the surface temperature was 1900 F. At a depth of 0.020 in., the temperature was 1600 F.; at 0.060 in., 1200 F.; and at 0.125 in., 800 F. To avoid loss of core properties, heating should be completed in 1 sec. Since heating periods of 1 sec. are practical, the surface can be hardened by this method without softening, weakening, or tempering the adjacent core layer.

In addition to heat treating, high frequency heating is being used for sterilization and dehydration of foods, for the setting of cements, soldering, brazing, etc. It is evident that the potentialities of the method are very great.

—V. W. Sherman. *Trans.*, Electrochemical Soc., Preprint 86-22, Oct. 1944.

Isothermal Transformation of Steels

Condensed from a Paper of the Iron and Steel Institute

The transformation of austenite in steel at temperatures in the martensitic zone was investigated with a recording dilatometer, in connection with hardness measurements and microscopical studies, to determine some of the S-curve phenomena.

The velocity of crystallization, or of recrystallization, is well understood. At transformation temperature crystallization may be delayed indefinitely. As the temperature falls the velocity of the transformation increases more or less rapidly. At a still lower temperature the velocity of change falls off, due to decreased mobility of the system, and at last becomes negligibly slow. At these temperatures martensite has been shown to persist in quenched steels for many thousands of years.

The dilatometric curve of the transformation from austenite to martensite for a eutectoid plain carbon steel, quenched from 810 C. (1490 F.) in a bath at 200 C. (290 F.), starts with a small but initially rapid expansion. This quickly slows down, and a stage is reached in which further transformation temporarily ceases. A second period of expansion follows, becomes increasingly rapid, reaches a maximum velocity, then diminishes again.

The primary expansion can be correlated with the formation of the martensitic "case," which the authors have invariably found on the surface of carbon steels. The succeeding period of temporary stability corresponds with the period of induction in which further change to martensite is temporarily inhibited by the compression stresses exerted on the interior due to "casing." As these stresses are relaxed, breakdown of the austenite once more commences, slowly at first, then progressively faster. The final portion of the dilatometer readings indicate a diminished rate of change.

The tempering curve of a martensitic steel, quenched isothermally, differs greatly from one oil- or water-quenched. In the

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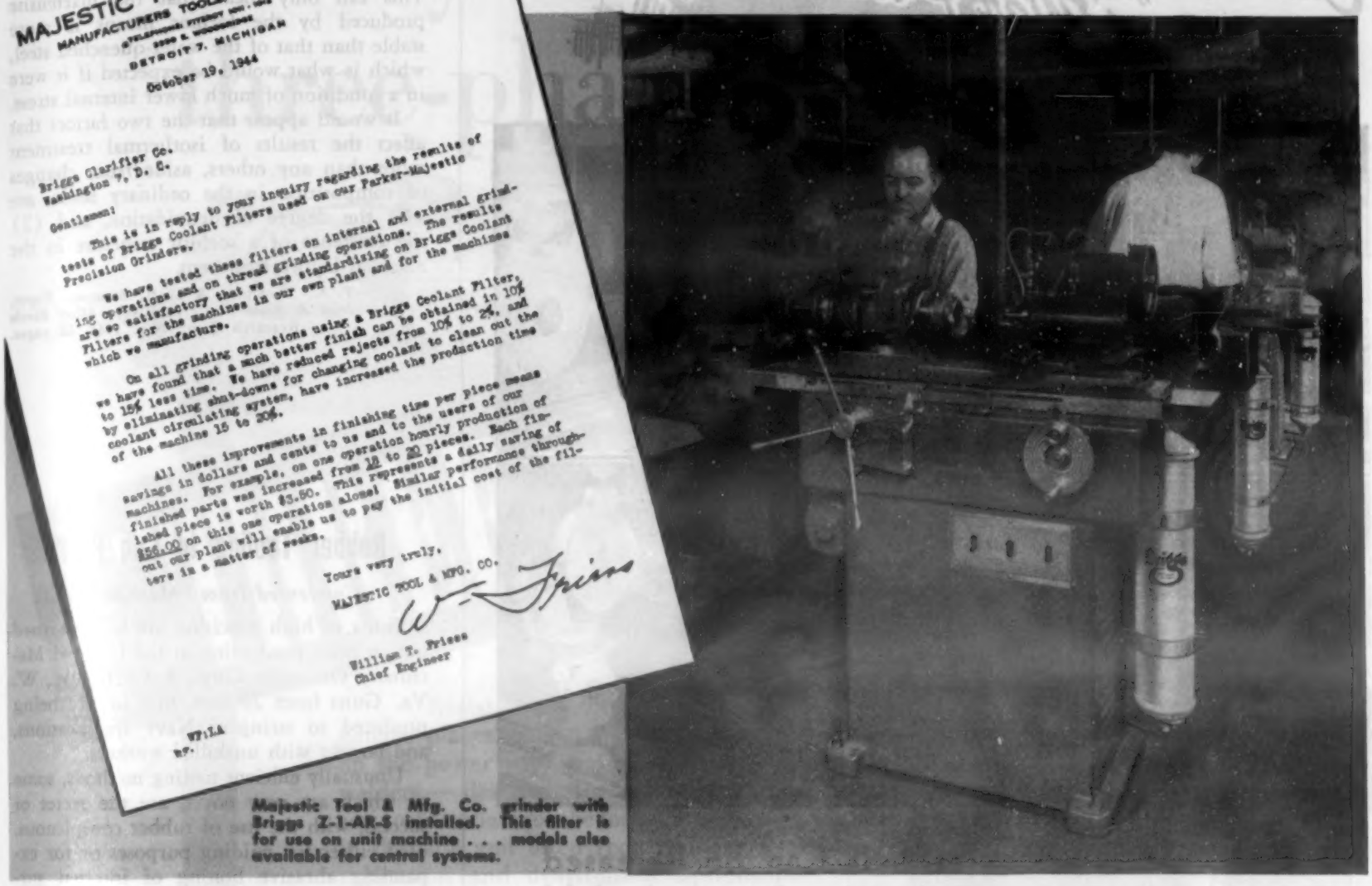
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October 19, 1944
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Washington 7, D. C.
Gentlemen:
This is in reply to your inquiry regarding the results of tests of Briggs Coolant Filters used on our Parker-Majestic Precision Grinders.
We have tested these filters on internal and external grinding operations and on thread grinding operations. The results are so satisfactory that we are standardizing on Briggs Coolant Filters for the machines in our own plant and for the machines which we manufacture.
On all grinding operations using a Briggs Coolant Filter, we have found that a much better finish can be obtained in 10% to 15% less time. We have reduced rejects from 10% to 2%, and by eliminating shut-downs for changing coolant to clean out the coolant circulating system, have increased the production time of the machine 15 to 20%.
All these improvements in finishing time per piece means savings in dollars and cents to us and to the users of our machines. For example, on one operation hourly production of finished parts was increased from 12 to 20 pieces. Each finished piece is worth $3.50. This represents a daily saving of $56.00 on this one operation alone! Similar performance throughout our plant will enable us to pay the initial cost of the filters in a matter of weeks.
Yours very truly,
MAJESTIC TOOL & MFG. CO.
William T. Friess
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Majestic Tool & Mfg. Co. grinder with Briggs Z-1-AR-S installed. This filter is for use on unit machine . . . models also available for central systems.

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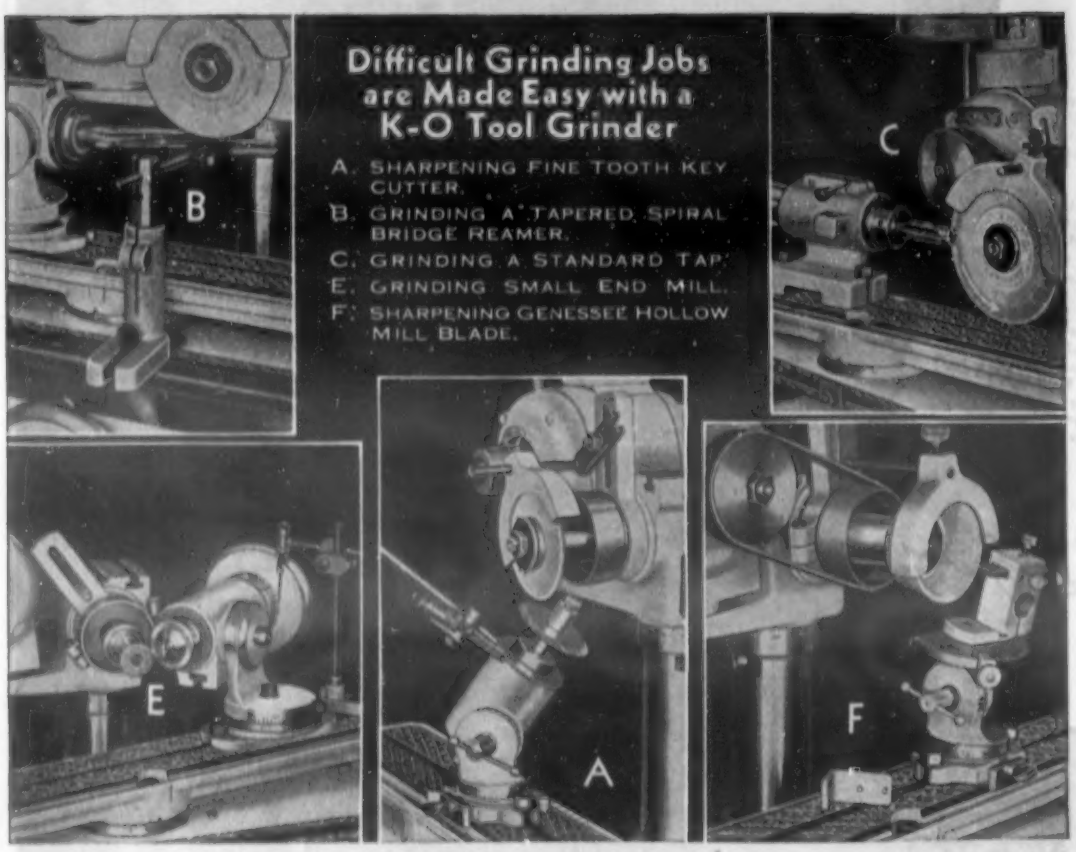
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Single Speed or Multi Speed Wheel Heads are available. Wheels ranging from 1 to 10 inches can be used. Tools from the smallest to 12 inches in diameter can be ground with speed and accuracy.

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former there is little or no evidence of contraction between 100 and 200 C. (212 and 390 F.), owing to the martensitic inversion.

The hardness figures for a given steel quenched in a molten metal bath, then re-tempered, are appreciably higher than that of water-quenched material similarly treated. This can only mean that the martensite produced by the former means is more stable than that of the water-quenched steel, which is what would be expected if it were in a condition of much lower internal stress.

It would appear that the two factors that affect the results of isothermal treatment more than any others, aside from changes of composition in the ordinary sense, are (1) the degree of deoxidation, and (2) the existence of a sorbitic structure in the material before treatment.

—F. C. Thompson & L. R. Stanton. Paper, *Iron & Steel Inst.*, (British), Alloy Steels Research Com., Nov. 1944, 38 pages.

Rubber Tooling in Gun Plant

Condensed from "Machinery"

Guns of high precision are being turned out in mass production at the General Machinery Ordnance Corp., S. Charleston, W. Va. Guns from 20 mm. to 6 in. are being produced to stringent Navy specifications, and largely with unskilled workers.

Unusually efficient tooling methods, some of which are very novel, are the secret of success, with the use of rubber conspicuous, used either for guiding purposes or for expanding abrasive honing of internal surfaces.

It is used instead of the conventional hard maple for the packed bit-tools used in boring. Rubber is applied in the form of four molded blocks, two being mounted on each side of a central steel frame to which two cutter bits are attached on one end and the shank on the opposite end. They are flat where in contact with the frame and semi-circular where they engage the gun bore.

After mounting, the rubber blocks are ground in a cylindrical grinding machine to a diameter 0.008 in. larger than the bore to be machined. But first the muzzle end of the gun is bored with a single point tool for 8 in. to provide a bearing surface for the rubber packs. From then on the rubber packs guide the tool.

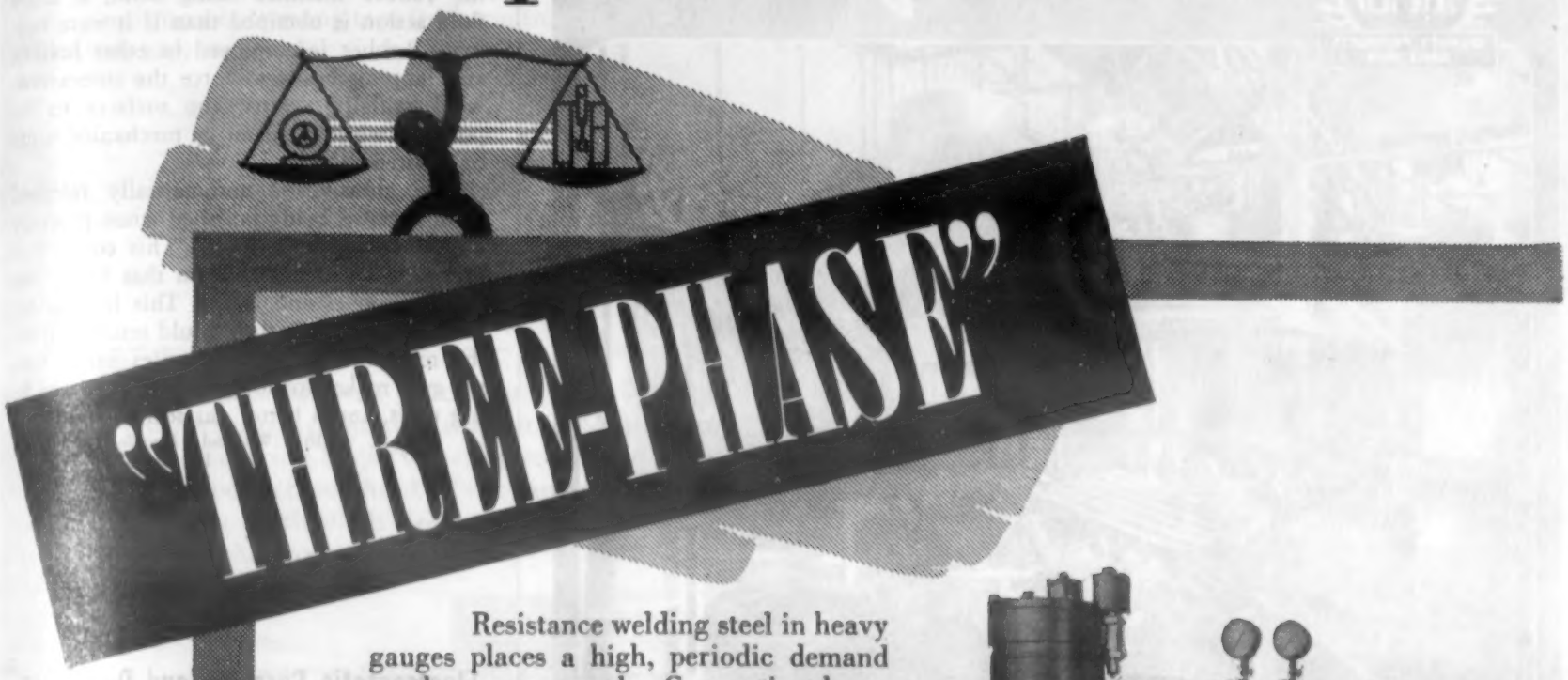
Rubber packing lasts much longer than the hard wood blocks used conventionally. The latter become oil-soaked and expand to a greater diameter than desired. They usually are discarded after one operation.

Rubber uses the oil for lubricating the sliding surfaces, but repels it against soaking into the interior. Rubber is used for five guns and can then be shimmed to bring the diameter up to size for regrinding.

Again, the wood packing gives out annoying squeals during operations, while the rubber is silent. The rubber blocks are molded from Neoprene and have a durometer reading of 90. A steel insert aids the attaching of the rubber blocks to the steel frame of the boring tool. Cuts up to

NOW . . . RESISTANCE WELDING WITH AN

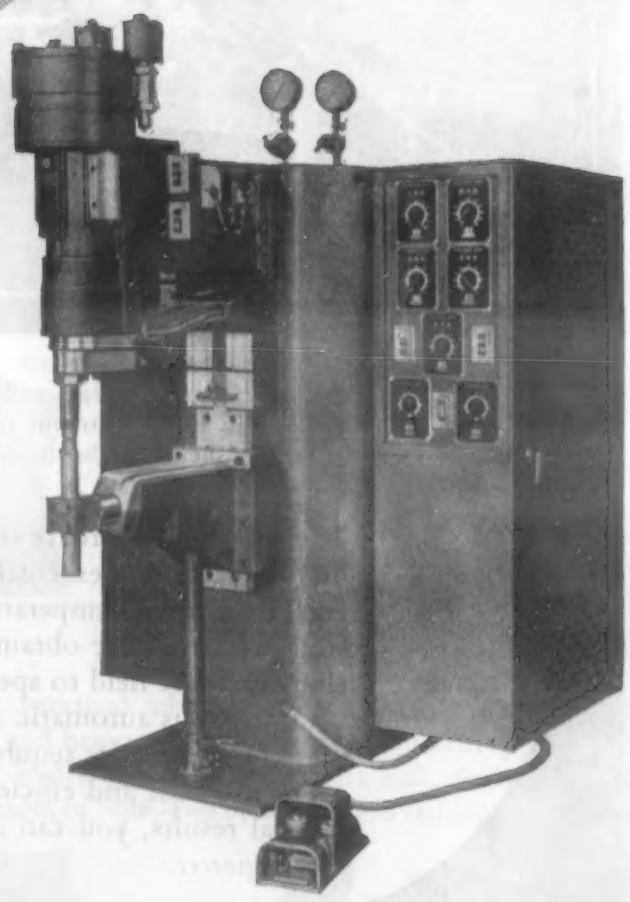
evenly balanced three-phase load . . .



Resistance welding steel in heavy gauges places a high, periodic demand on the power supply. Conventional a.c. welders — designed for single phase — seriously unbalance the load, cause flicker in the line and often require expensive substation and distribution equipment.

Sciaky "THREE-PHASE" welders employ a principle enabling them to take practically an equal amount of current from each phase of the power supply, thus operating on a ***balanced load.*** An ideal low frequency welding current is produced first by converting to d.c. then reconverting to an alternating impulse. This system also provides operation at high power factor (80 to 85%) and decreased actual power demand.

The Sciaky "THREE-PHASE" Welder illustrated is designed for high quality spot welding on mild and stainless steels and rusty and scaly stock in thicknesses from .032" to .312". Rating is 100 KVA at 50% duty cycle, operating at 85% power factor. Speed on two thicknesses of .062" mild steel is 90 spots per minute. Special features include Variable Pressure with a maximum pressure of 5.000 lbs., and adjustable Preheating Current.



Write for bulletin 204-A describing fully the principle of the Sciaky "THREE-PHASE".

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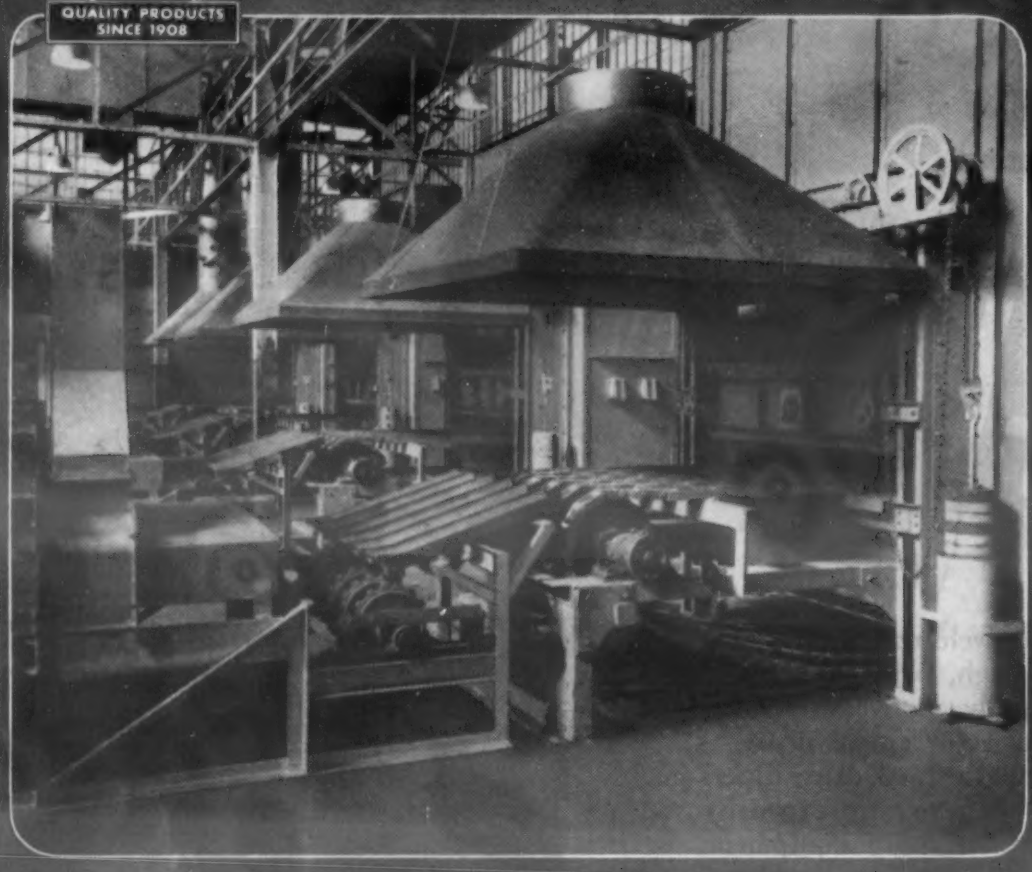

Illustration: Discharge ends of convection type draw furnaces where the heat treatment of heavy artillery shells is completed after the shells are hardened and quenched.

The continuous furnace is a production line machine which not only eliminates costly materials handling, but lends itself to accurate temperature control as well. Uniform physical properties are obtained in the process. Ductility and elongation are held to specified limits.

Continuous automatic operation throughout each of the four complete units requires a minimum of manpower.

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½ in. deep are taken in rough-boring, with up to 0.070 in. deep in finishing.

In grinding the rubber packing to the required diameter, a fairly rough grinding wheel is used, the work revolving at not more than 75 to 80 r.p.m. The feed of the table should be about equal to the width of the grinding wheel for every three revolutions of the work.

An ingenious head has been developed for honing torpedo air flasks in the center of which is a rubber doughnut, used in conjunction with abrasive stones. Because of the rubber member being solid, a more fluid action is obtained than if it were hollow. Rubber is employed in other honing and lapping heads to force the stones outward radially against the surfaces to be polished without the aid of mechanical arms or other devices.

The abrasive is automatically released from surfaces being polished when pressure on the rubber is reduced. This concern is the only naval gun concern that hones the rifling grooves and lands. This honing removes raspy edges that would tend to shave the rotating ring on projectiles fired from the gun, makes for longer life of the broaching tools, and a better gas seal when firing.

—Alfred Weiland. *Machinery*, Vol. 51, Dec. 1944, pp. 148-155.

Electrostatic Spraying and Detearing

Condensed from "The Iron Age"

Electrostatic spraying has a certain similarity to electroplating, in that paint is deposited upon the work as it passes through a charged field. A voltage of 100,000 or more is necessary to give minute spray particles a charge. Consequently, they are attracted to the work, which has been given an opposite polarity. Wasteful overspray is virtually eliminated.

Parts are carried on conveyors through an electrostatic field, which is created by vertical electrodes. Paint is drawn to all sides of the parts simultaneously. Somewhat better results may be obtained by revolving the parts in the field.

This method of painting is highly efficient and causes paint to be spread more smoothly than was possible in the past. In general, a thinner, more flexible film is applied, reducing the risk of chipping.

The degree of economy that can be attained by electrostatic spraying to a large extent depends upon the shape and size of the articles. With small parts, ordinary spraying methods frequently waste 50 to 90% of the material. Less saving is effected on large, flat parts, and it is possible that in the spraying of metal sheets, hand spraying would be more efficient.

In electrostatic detearing, work is carried by conveyor over a drain board and is allowed to drain until tears are formed at drain-off points. It is next passed over a grid to which an electric current of low amperage and high voltage (85,000 v.) has been applied. As the work passes through the field, excess paint is drawn off and a smooth coating results.

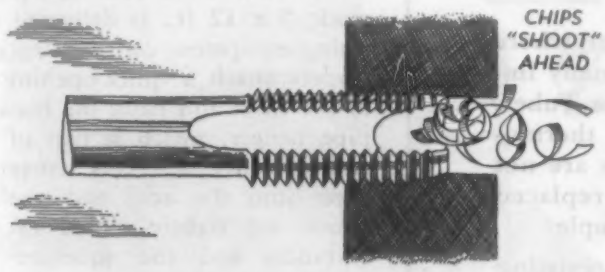
NEW TAP, DEVELOPED FOR BOTTOMING HOLES IN STRINGY MATERIAL, SOLVES OLD PROBLEM

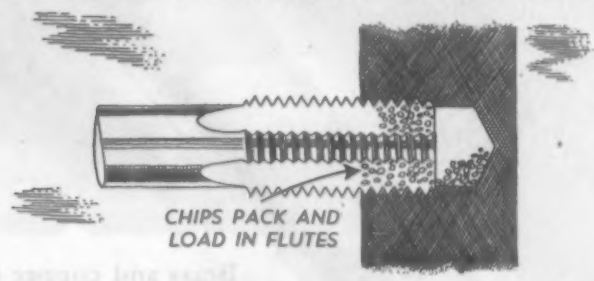
SHOW-HOW REPORTS

1 On a routine call at an aircraft factory, "Greenfield" distributor's salesman was told—in casual way—that production could be speeded up on a certain job except for traditionally poor performance of ordinary bottoming taps in threading blind holes in stringy materials.

2 Conversation was repeated to "Greenfield Man" in that territory who in turn took it up with "Greenfield" engineers at home office. In spite of fact that this was an accepted limitation of ordinary bottoming taps, "Greenfield" research laboratory tackled this old problem again.

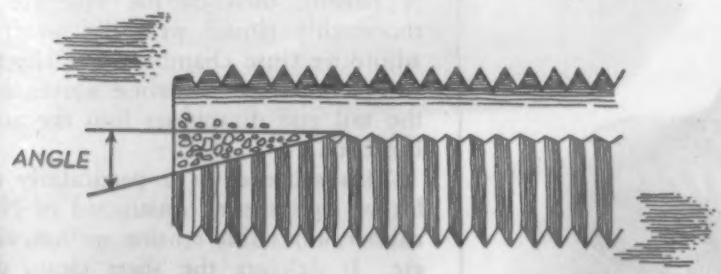
3 Experience showed that "Gun" tap with its clean shearing action was ideal for this material but that cutting angle which gives this shearing action shoots chips ahead of the tap, normally restricts use to through holes or blind holes with plenty of chip room at bottom.

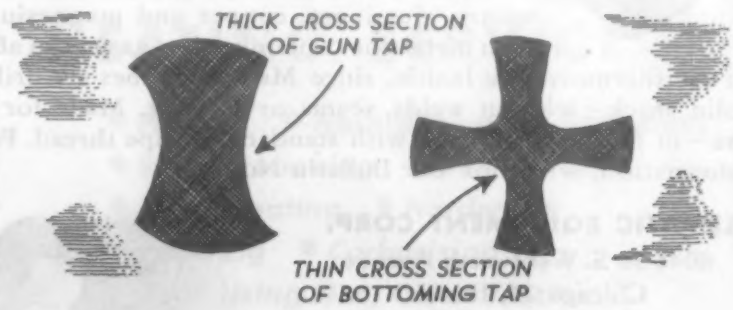




4 Action of ordinary bottoming taps tends to "load" chips in flutes, causing torn threads at bottom of holes when chips pack down; traditionally accepted as unavoidable. These taps are also somewhat more susceptible to breakage because of smaller cross-sectional metallic area than "Gun" taps.

5 "Greenfield" researchers working on theory that "Gun" shearing action combined with chip breaking action would solve this problem; finally developed a cutting angle on a bottoming "Gun" tap which gave desired result. Additional flute space at point of tap provided extra room for chip disposal.





6 New tap retained advantages of "Gun" tap's shearing cut and heavy cross-sectional metallic area for maximum strength, tap could cut full clean thread to bottom of hole. Tap breakage was reduced.

Results:

(1) Aircraft manufacturer found new "Bottoming Gun Tap" could be used on screw machines putting whole operation on production basis for first time . . . (2) New tap, tested on similar operations in plants of business machine and optical instrument manufacturers, gave same gratifying results. "Greenfield" could SHOW HOW problem had been solved before . . . (3) A new and valuable tool was added to "Greenfield's" line.

"Greenfield's" SHOW-HOW is KNOW-HOW in action!

ON THREADING PROBLEMS, CALL YOUR "GREENFIELD MAN" THROUGH YOUR "GREENFIELD" DISTRIBUTOR!

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Metalast

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Brass and copper foundries everywhere report they are getting twice as many immersions since changing to Metalast Tubes. This means they are saving on their thermocouple cost as well, for Metalast Tubes are not connected to the thermocouple and can be replaced without damaging or discarding thermocouple.

Metalast Protection Tubes are made of a heat resisting alloy and will stand repeated immersions in molten brass, bronze, aluminum, copper and magnesium. Neither slag, molten metal nor contaminating gases can affect the accuracy of the thermocouple inside, since Metalast Tubes are drilled from special solid stock—without welds, seams or forging. Made for furnace or ladle use—in 6″ and 8″ lengths with standard ½″ pipe thread. For more detailed information, write for our Bulletin No. 500.

ELEMATIC EQUIPMENT CORP.
6046-50 S. Wentworth Avenue
Chicago 21, Illinois

Detearing electrostatically has made it possible to dip many parts that it was necessary formerly to spray at much higher cost. Electrostatic detearing and spraying are done in the same production line. The same electrical equipment is used for both with only minor changes necessary.

—Harry Forsberg. *Iron Age*, Vol. 154, Oct. 19, 1944, pp. 50-54.

Priming Sheet Stock

Condensed from "Mill and Factory"

Aluminum alloy sheets are etched, washed and primed with zinc chrome primer in mass production methods at the Douglas Santa Monica plant. The equipment, called the "merry-go-round," flow-coats as high as 1400 sheets in one 8-hr. shift, or a coverage of almost 17,000 sq. ft.

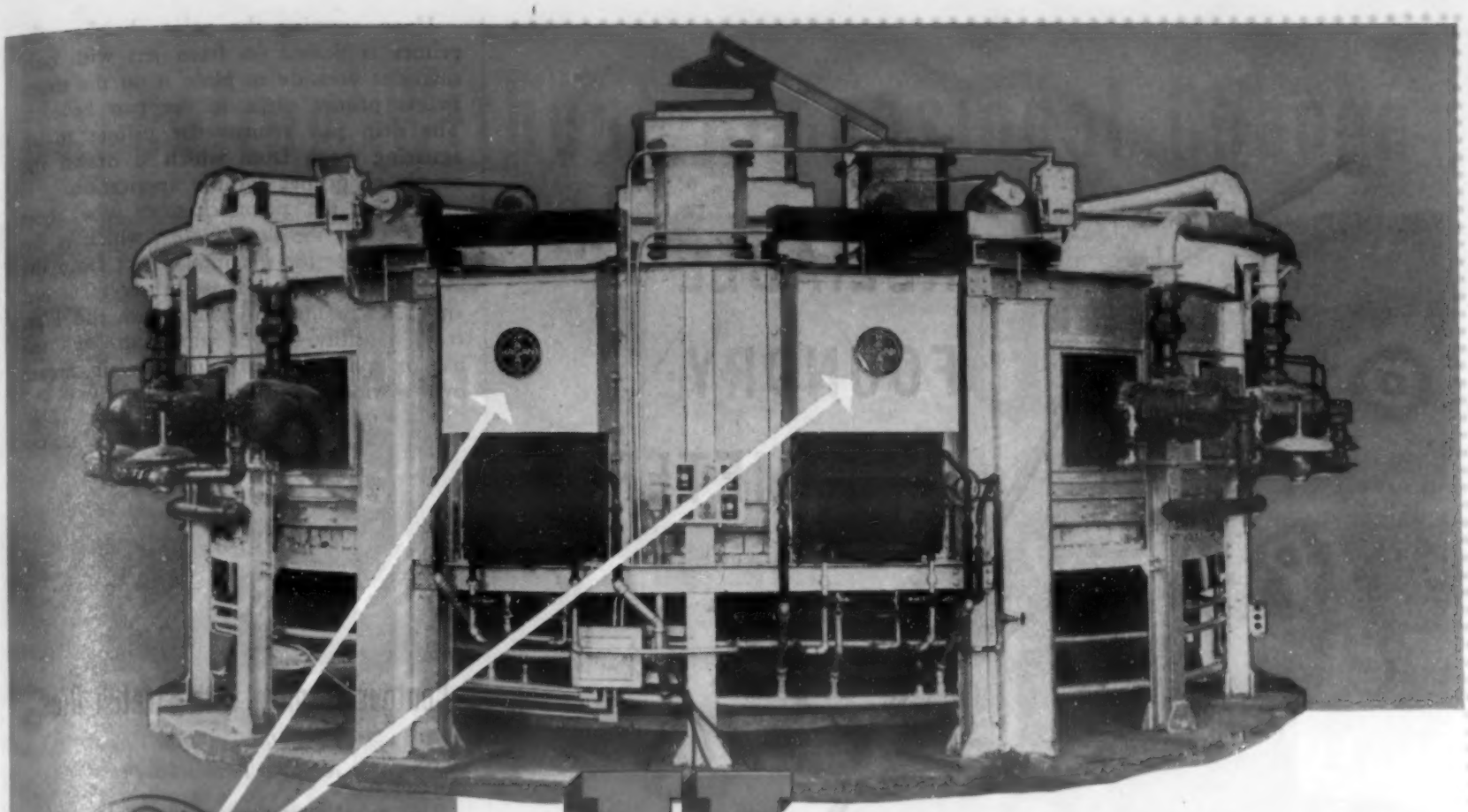
Previously, the treatment was given the sheets after they had been fabricated. The primer was put on by various and non-uniform methods, such as spraying, roller-coating, dipping, flow-coating or hand-brushing. Sometimes two or more methods were used on one fabricated part of the airplane.

By the new method the equipment sheet stock, 5 x 12 ft., is delivered to the processing equipment on shop trucks. Here the loaders attach a quick-opening clamp-hook to the sheet and hang the hook on a 12-ft. pipe hanger, which is part of the moving endless conveyor. This hanger carries the sheet into the acid and wash chambers, which are tightly closed except for the entrances and the squeegee exits. The chambers are drained separately to their individual tanks.

The hot phosphoric acid is pumped from its collection tank and distributed in jets from the four feed pipes to both sides of the traveling sheet, no part of the surface being missed. Before the tail end of the sheet enters the acid chamber, the front end is passing through the squeegee and is thoroughly rinsed with hot water in the adjoining rinse chamber. The sheet begins to emerge from the rinse squeegee just as the tail end disappears into the acid etching bath.

This squeegee is a particularly effective bit of equipment, constructed of Neoprene rubber, adjustable tension springs, air hoses, etc. It delivers the sheet clean, dry and ready for the primer. Considerable thought was given to change the direction of the sheet in process for the painting operations to follow. Limited space made the problem difficult.

The ingenious arrangement perfected required that the 12-ft. pipe hanger or bracket be suspended and pivot from its center. Its front end followed guides. Thus, when the center pivot on the conveyor reaches the turning wheel, it continues around the wheel while the guides hold the front end in a slot. The moving conveyor swings the back end of the sheet in the general direction the conveyor is moving. The former front end, held in its guides, trails within the limits of its guides until it is in position for the return trip.



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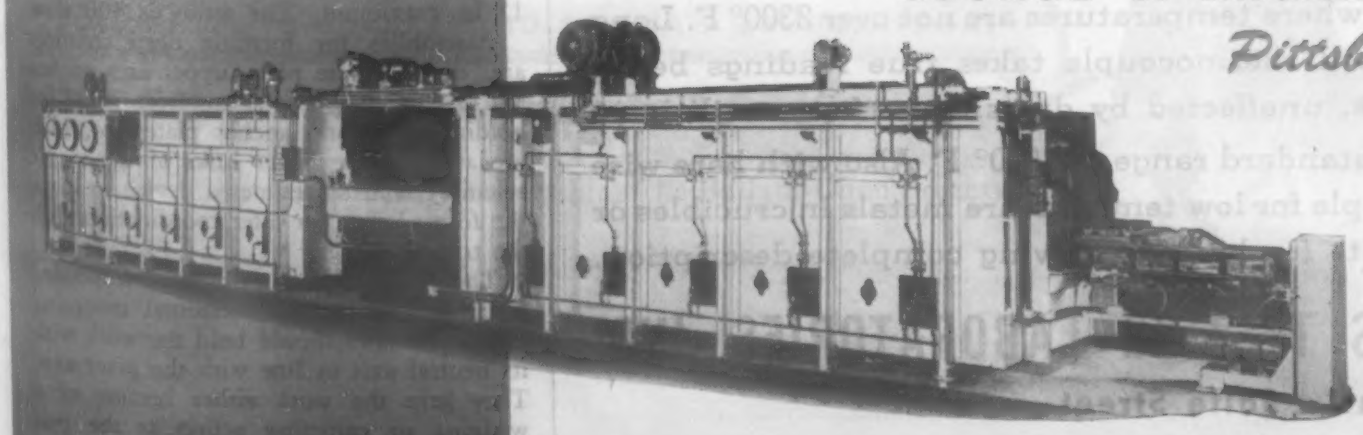
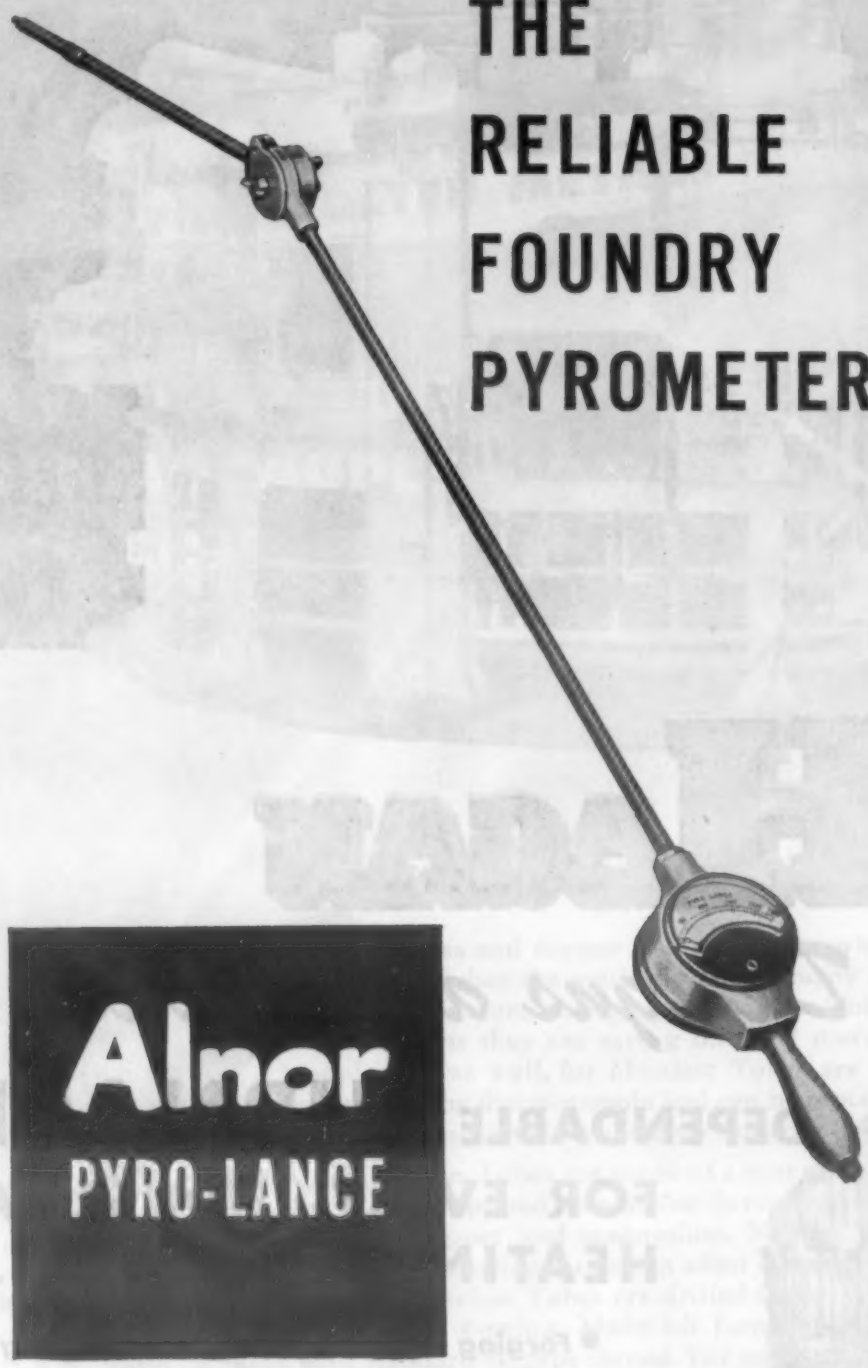


DETROIT LOS ANGELES CHICAGO SAN FRANCISCO



THE RELIABLE FOUNDRY PYROMETER

Alnor PYRO-LANCE

The Alnor portable Pyro-Lance is a rugged, durable, portable pyrometer built with shock-resisting movement and enclosed extension thermocouple. It stands up in foundry service and gives the accurate temperature readings essential to low-cost production of sound castings. Especially suited for use on molten brass, bronze, copper, aluminum bronze, magnesium alloys, and similar metals where temperatures are not over 2300° F. Long life, enclosed thermocouple takes true readings below the surface, unaffected by dross or surface conditions.

Built in standard range, 0-2500° F. Also with bare wire thermocouple for low temperature metals in crucibles or ladles. Write for bulletins giving complete description.

ILLINOIS TESTING LABORATORIES, INC.

420 North La Salle Street

Chicago 10, Illinois

Upon entering the paint chamber, the primer is flowed on from jets with only sufficient pressure to place it on the sheet. Excess primer drips to the pan beneath. The drip pan returns the primer to an agitating drum from which is drawn the supply of primer for the application.

Leaving the paint chamber, the sheet continues to the drying area, which is enclosed except for the intake duct from the exhaust. Then the drying sheet is turned and retraces until it comes into the blast from a utility blower which, through the use of splitters, distributes the air stream over a wide sheet area.

—G. B. Ashmead. *Mill & Factory*, Vol. 35, Nov. 1944, pp. 122-124.

Contour Forming with Stretch Dies

Condensed from "The Modern Industrial Press"

The metal stretcher or "stretch press" is the latest machine to be used for forming deeply contoured sections with "toggle" acting dies. Rolled shapes, extrusions or break-bent sheet sections may be formed into single directional curves, or flat stock may be given moderate cross curvature and deep longitudinal contour. The die is made in the approximate shape wanted for the finished part, then the material is stretched over it beyond its elastic limit and after release practically retains the shape of the die.

The purpose is to secure just sufficient elongation of the part to stretch it beyond the elastic limit while forming, so as to prevent buckling and practically eliminate spring-back after release of the jaws. The ideal stretching action gives the material a certain amount of stretch before the forming starts. Then the stretching should proceed as the forming takes place.

Typical equipment for sheet metal stretching has two massive anchor rails with flat upper faces provided with slots for hold-down bolts. Between them is a ram with a flat horizontal top face 17 x 96 in., with T-slots for attaching the form die.

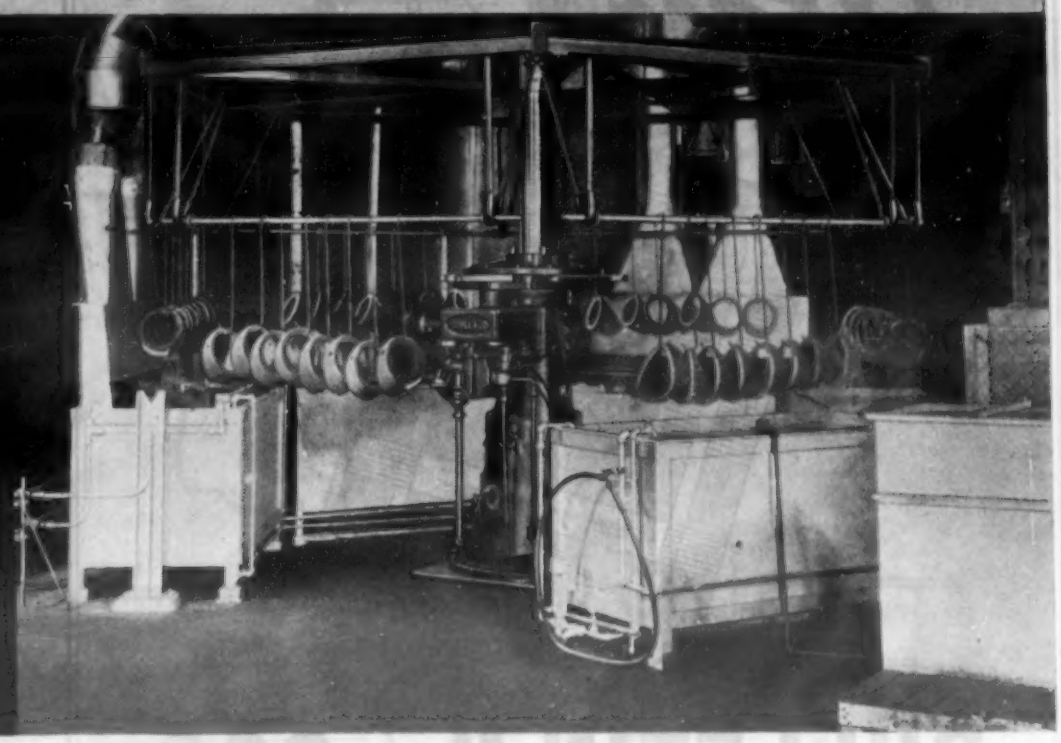
In operation, the anchor rails remain at a fixed height though they can be set at any horizontal spacing of from 22 to 83 in. apart. At the starting position of the ram its face is slightly above the anchor rails, having a controlled stroke upward of 12 in. maximum. The rating is 300 tons.

Assemblies for forming deep contours are: die, die base plate, upper arm anchor blocks, toggle arm assemblies, jaws for holding the work, anchor plates to which are attached the lower links of the toggle assembly, and sometimes a device to mark the formed part for later coordination with the trimming jig.

There should be a rigid frame suspended for free pivoting on horizontal mounting pins. The jaws should hold the work with its neutral axis in line with the pivot axis. They grip the work either because of a wedging or camming action as the pull starts.

Descaling Without Dimensional Change

AN ELECTRO-CHEMICAL "SCRUBBING" *that really gets behind the ears*



The Bullard-Dunn Process is the *only* process that completely frees ferrous metallic surfaces of scale and oxide without causing dimensional change.

HERE ARE SOME SALIENT FACTS

While the scale and oxide are being removed, a thin film of tin* deposits on the clean areas, completely protecting the work surface from attack. That's why no dimensional change takes place!

The tin film gives the process an unusually good throwing power. That's why it cleans out holes and recesses so well!

It employs current (low voltage). That's why it is so fast!

It does not attack the work surface after it is clean. That's why automatic conveyors can be used so successfully!

It is cheap and simple to operate. That's why it is so practical for any shop!

For further advantages and applications, write for Bulletin BD-42. Samples will be treated and the process demonstrated upon request.

*This tin film can be removed easily and quickly when desired, leaving the work surface chemically clean.

THE BULLARD-DUNN PROCESS IS USED FOR ALL THESE PURPOSES

1. When scale must be removed completely as for grinding, plating and inspection.
2. When no dimensional changes can be tolerated.
3. When internal surfaces must be cleaned out.
4. To clean and provide lubricant as in hobbing or drawing.
5. To clean and provide base for soldering, hot tinning or paint.

Only Bullard-Dunn descales without dimensional change

FULL FACTS IN BULLETIN BD-42—MAIL COUPON TODAY

THE BULLARD COMPANY, Bridgeport 2, Conn.

Please send me Bulletin BD-42 describing the Bullard-Dunn Process

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BULLETIN No. 200

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STERLING ALLOYS, Inc.
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The ram, with the form die mounted thereon, is placed in the "down" position while the ends of the work are fastened in the jaws at the ends of the upper toggle arms. The ram raises while the anchored ends of the toggles remain stationary. This lowers the jaws holding the ends of the work relative to the upward moving die, forming and stretching the piece over the contoured surface of the die. Parts to be formed deeper than 2½ times the ram travel may best be formed in two or more stages.

There should be no relaxation at any point, and the elongation rate should increase at the end of the stroke. Toggle arms are designed with a length and location to provide the needed stretching action.

—R. W. Osborn. *Modern Industrial Press*, Vol. 2, Nov. 1944, pp. 31-32.

Copper Wire Drawing Lubricants

Condensed from "Wire and Wire Products"

Even after a satisfactory copper wire drawing lubricant has been found, it is necessary to consider the following important factors to maintain good performance: (1) Condition of the water; (2) maintenance of the Babcock test percentage within prescribed limits; and (3) maintenance of the pH in the proper range.

The water is most important, as wet lubricants are generally over 90% water. Attention must be paid to condition of the water, size and construction of the reservoir, whether cooling capacity is great enough, speed of drawing, foam generation, etc. Hard natural waters not softened by the city may be softened by the zeolite principle, which gives splendid results if the system is cared for and checked regularly.

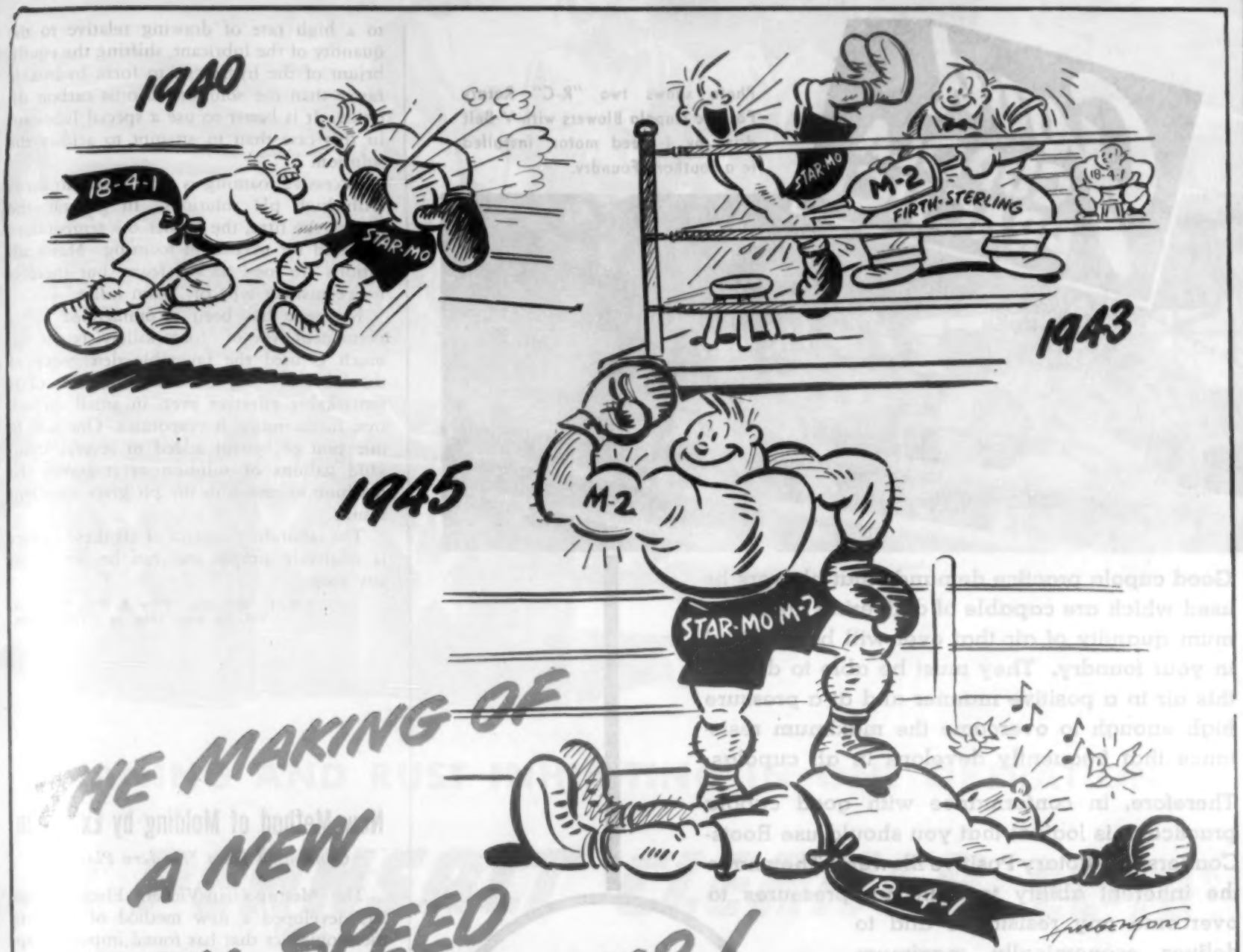
If the zeolite is near saturation, there is likely to be a precipitation of the soap of the lubricant, and the stability of the fat emulsion is affected. This will cause clogging of the dies and sticky rolls. It is preferable to use continuously softened water rather than a batch softener. A softener can be incorporated in the lubricant, but this practice is too inflexible for general usage.

The Babcock test shows the total percentage of soap and fat in the solution. Soap titration values are not reliable as an indication of the actual soap exclusive of the fat, but they will show any sudden changes.

A pH of 8.5 to 10 is generally satisfactory. An electrometric test is preferable to a colorimetric, due to the occurrence of colored or turbid solutions. If the pH is too low, there will be excessive copper soap formation, which will gum the dies and rolls and lead to breaks and dirty wire.

Additions of alkali may be required, although the lubricant should be so composed that normal additions of the lubricant will take care of the pH. Too high pH will cause poor lubrication, high die wear and inadequate lubricant adsorption. The pH value is a maximum in the freshly made solution and usually drops due to absorption of carbon dioxide.

If the pH stays high or increases, it is due



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STAR-MO M-2

Improved TUNGSTEN-"MOLY" HIGH-SPEED STEEL

Ever since the new "M-2" analysis was adopted for tungsten-molybdenum high-speed steel, more and more manufacturers in the automotive and tool-making fields are recognizing with approval and satisfaction this new Firth-Sterling champion, STAR-MO M-2.

They have seen this new steel in action. They find it excels 18-4-1 in their plants. They are supporting it with enthusiasm because it is giving satisfactory performance continually, and adding new accomplishments to its record. Why not give STAR-MO M-2 a try-out in your shop?

STAR-MO M-2 is *Better*

- Outcuts and outlasts 18-4-1 high-speed steel on most applications.

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- Base price is 14% less than 18-4-1 steels, and weight is approximately 7% less per foot. Let us quote.

STAR-MO M-2 is *Easy to Handle*

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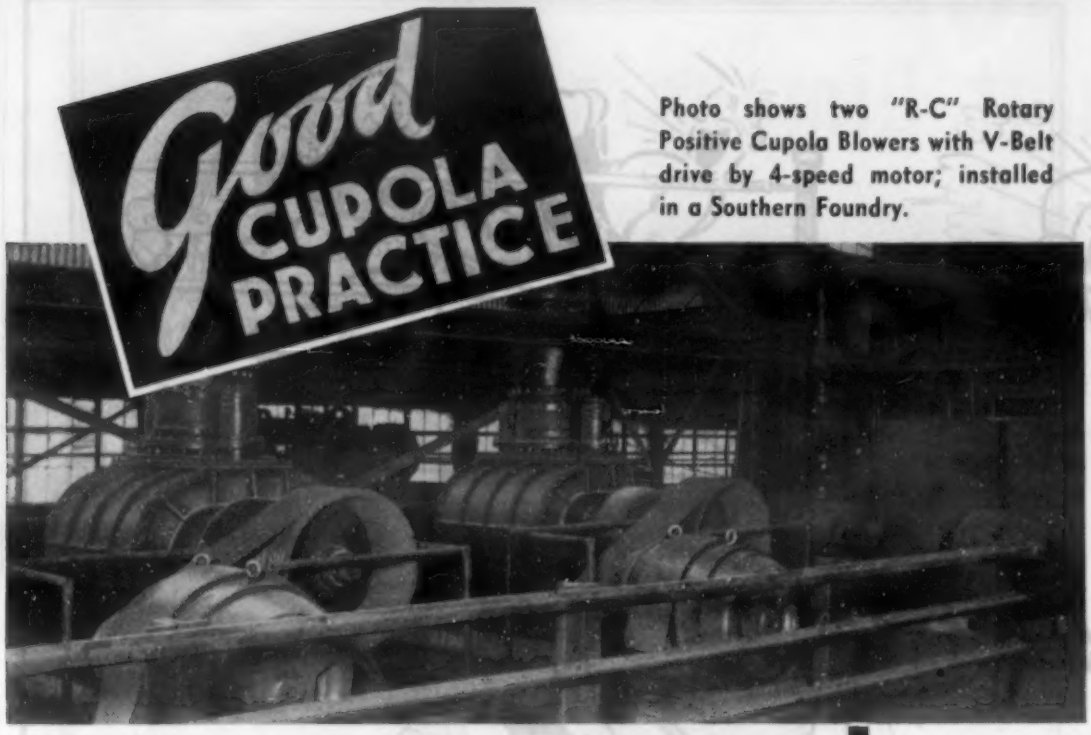

Photo shows two "R-C" Rotary Positive Cupola Blowers with V-Belt drive by 4-speed motor; installed in a Southern Foundry.

Good cupola practice demands that blowers be used which are capable of delivering the maximum quantity of air that ever will be required in your foundry. They must be able to deliver this air in a positive manner and at a pressure high enough to overcome the maximum resistance that frequently develops in all cupolas.

Therefore, in conformance with good cupola practice, it is logical that you should use Roots-Connersville Rotary Positive Blowers. They have the inherent ability to build up pressures to overcome any resistance and to deliver economically maximum quantity of air to meet any condition by simply changing the speed. Their rugged construction and high quality of workmanship enables them to deliver in excess of their rated capacities for short periods, if necessary.

In addition, they are built to give years of trouble-free service. Write for Bulletin 22-B-12.

ROOTS-CONNERSVILLE BLOWER CORPORATION

One of the Dresser Industries
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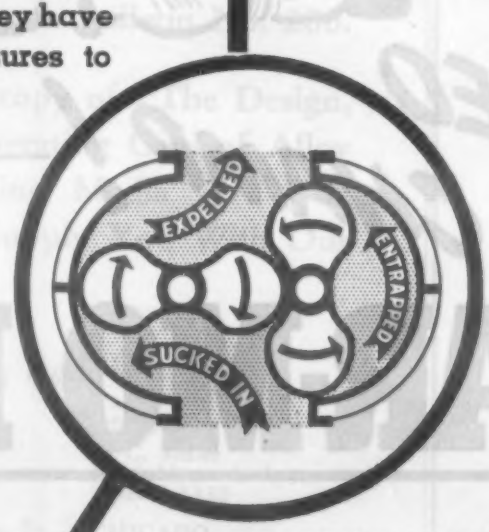
Connersville, Indiana



POSITIVE DISPLACEMENT

Twin impellers alternately suck in, momentarily entrap, and then expel definitely known amounts of air, resulting in positive delivery of four equal volumes each revolution of drive shaft. Impellers need no seal or lubrication. Capacity varies with speed. Pressure automatically builds up to overcome resistance on discharge side.

Roots CONNERSVILLE SINCE 1854 Positive Displacement CUPOLA BLOWERS

to a high rate of drawing relative to the quantity of the lubricant, shifting the equilibrium of the hydrolysis to form hydroxide faster than the solution absorbs carbon dioxide. It is better to use a special lubricant in this case than to attempt to acidify the solution.

Excessive foaming is most likely to occur with high pH solutions. In general, the higher the titre, the higher the temperature required for maximum foaming. Many additions are used to kill foam, but there is no permanent type of "foam killer."

Kerosene has been recommended for a permanent type of "foam killer," but if too much is used the favorable detergency of the lubricant may be destroyed. Benzol is remarkably effective even in small quantities; furthermore, it evaporates. One-half to one pint of benzol added to several thousand gallons of solution as it leaves the machine to return to the pit gives excellent results.

The laboratory control of all these factors is relatively simple and can be set up in any shop.

—R. C. Williams. *Wire & Wire Products*, Vol. 19, Nov. 1944, pp. 771-772, 805.

New Method of Molding by Extrusion

Condensed from "Modern Plastics"

The Metropolitan-Vickers Electrical Co. has developed a new method of molding thermoplastics that has found important applications in war production. This method has been confined to the manufacture of polyethylene molding, but it may be used for other thermoplastic materials.

The essential difference between this process and present compression, transfer and injection methods lies in the fact that molding is done at low pressure, 200 to 400 p.s.i., which can easily be regulated to suit a variety of articles.

When the mold is full, it is important that pressure inside that mold be maintained during the cooling period to make up for contraction of the material. This is important if molding is large. Small clearance is provided between the screw and barrel for mechanical reasons and to allow for slip of the material when the mold is filled.

Since the machine is a continuous type, large moldings can be made by a small machine with relatively low initial cost. Owing to the low pressure used, molds may be constructed of light brass or low-grade steel.

A typical machine is made by David Bridge & Co., and driven by a Metropolitan-Vickers variable speed motor through a double reduction-gear box. The whole assembly is easily dismantled. Hopper, barrel and container for raw material are heated electrically.

Nozzles used are plain and automatic. When the plain nozzle is used, the machine must be started after the mold has been clamped on and stopped before the mold is removed. In the case of the automatic nozzle, the machine can be run continuously.

In case of repetitive work, the machine

CLEANING AND RUST INHIBITING IN ONE OPERATION

with PENNSALT CLEANER EC-10*

Reg. U. S. Pat. Off.

Preparing "blitz cans" for welding presents a tough cleaning problem. Oil and grease must be removed, and the surface must be capable of receiving an even weld without rust from the coolant water used on the welding machine. Penn Salt's technical staff helped this manufacturer of "blitz cans" solve the problem.

A concentration of one part Pennsalt Cleaner EC-10 to 100 parts of water was used in a spray washing machine. This produced a very clean part with sufficient rust protection to last until the subsequent operation. So satisfactory was the result, that Pennsalt Cleaner EC-10 was promptly re-ordered.

How about *your* cleaning problem? Penn Salt's technical staff is at your service without obligation. Acid, Alkaline and Solvent-Type Pennsalt Cleaners are noted for their ability to solve difficult problems quickly, effectively, economically. Write fully to our Special Chemicals Division, Dept. MA.

SPECIAL CHEMICALS DIVISION PRODUCTS

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*Patent Applied for

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The advice and help of Barrett technical service men are available to you for the asking.

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Free: *An interesting and helpful booklet, packed with useful information about Anhydrous Ammonia, will be mailed to you free on request.*

should be provided with two or three automatic nozzles. In the case of a single nozzle machine, one operator carries out the whole operation and dismantling of the mold.

In case of a 3-nozzle machine, two operators are used. One is in charge of molding and the other carries out the dismantling.

This method of molding should be regarded as supplementary to, rather than as competitive with, the present known methods.

—A. D. Ferguson. *Modern Plastics*, Vol. 22, Dec. 1944, pp. 186, 206.

Decorative Anodizing

Condensed from "Canadian Metals and Metallurgical Industries"

Anodic oxidation of aluminum is similar to electroplating except that the metal itself is made the anode in an electrolyte capable of yielding oxygen on electrolysis. The nascent oxygen liberated combines with the surface of the metal to form a glass-like film of aluminum oxide which, integral with the surface, cannot chip or peel as can plated coatings.

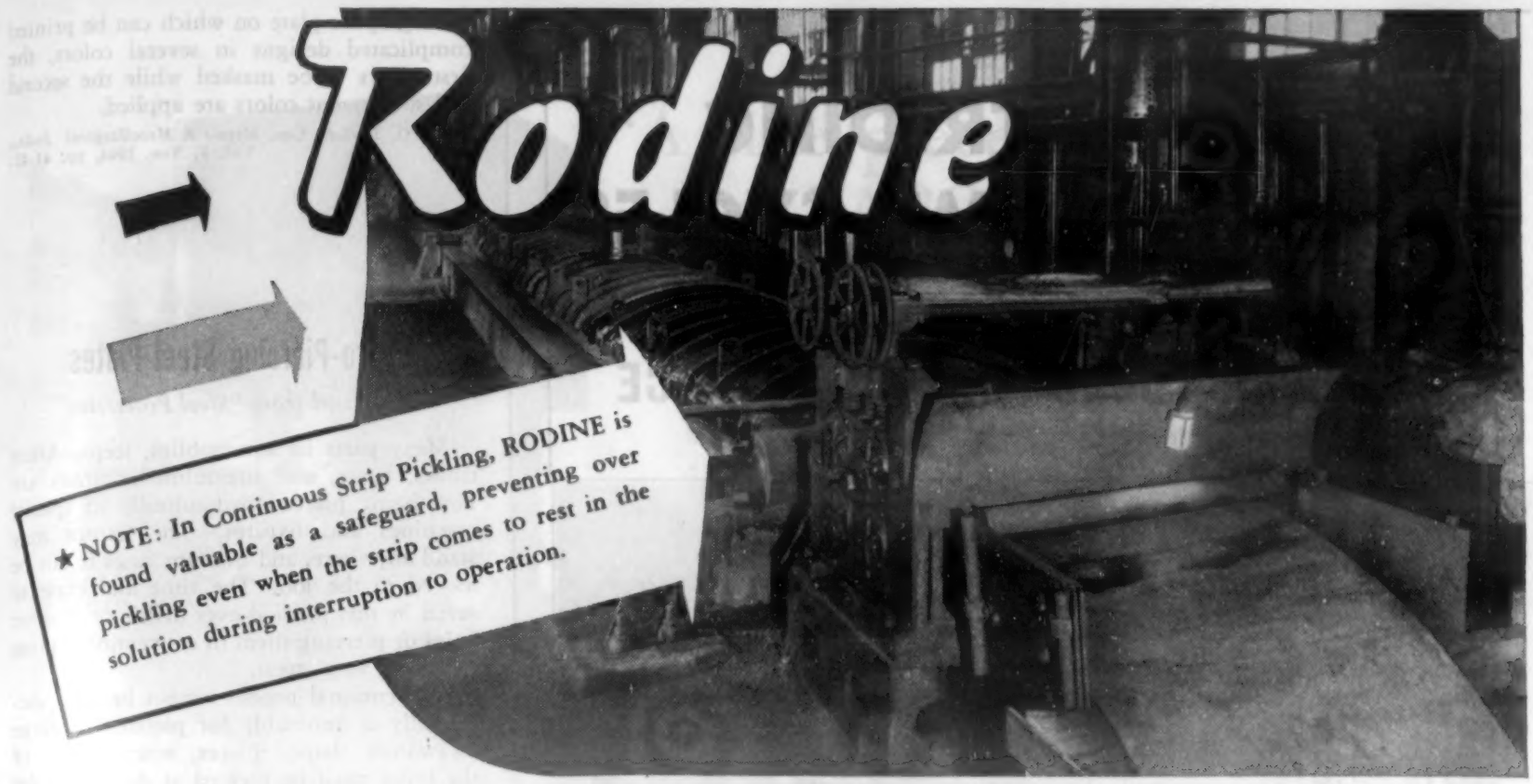
When subjected to the salt spray test this coating will remain unaffected for 12 to 18 months, equivalent to many years of ordinary atmospheric exposure. Moreover, if a solution of sulphuric or oxalic acid is used as the electrolyte, the film can be built up to a thickness of 0.05 mm. or more, and can be of a hardness such that glass can be scratched with a piece of anodized soft aluminum.

The film is electrically insulating, minutely porous, and can act as a mordant for organic dyestuffs. Again, by precipitating colored metallic salts within the porous structure by double decomposition reactions a further group of colored effects can be derived. It is suitable for photographic reproductions, multi-colored finishes, electrolytically brightened reflectors and surface preparations prior to anodizing.

Fine silver white satin matte finishes are obtained by controlling etching of the metal, either chemically or electrolytically, while smooth reflective or semi-reflective silver surfaces are produced on surfaces that have been mechanically polished and in some cases further brightened by electrolytic polishing. Normally, the reflectivity of polished aluminum is 70% that of silvered glass, but by electrolytic brightening and subsequent anodizing in a special electrolyte it can reach 86%.

The largest general outlet will be in architecture and domestic utilities. Since cost will be less than for stainless steel, it will be practical for store fronts and fittings. It can be used for house decorative hardware, lighting fixtures, handrails, paneling, etc., and can be provided with a tint suitable to the surroundings. Kitchen cooking utensils can be given a dark enough shade so that stains will not show. It will be suitable for marine use.

The porous film can be impregnated with light sensitive salts, such as the silver halides, the metal then to be used as a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★ NOTE: In Continuous Strip Pickling, RODINE is found valuable as a safeguard, preventing over pickling even when the strip comes to rest in the solution during interruption to operation.

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RODINE permits the use of stronger acid concentration and higher temperatures without danger of over pickling or etching thereby speeding the process and increasing output.

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RODINE-controlled pickling produces a smooth, bright, clean surface. There is no pickling condition which is not improved with Rodine, except where deep etching is desired. Rodine confines the action of the acid in the pickle bath to removal of scale thus minimizing the acid attack on clean metal and overcoming deep pitting and embrittlement.

There are types of **RODINE** suited to the varying pickling problems. The experience of ACP Technicians is at your service to recommend the Rodine and method best suited to meet your needs if you will write in detail to

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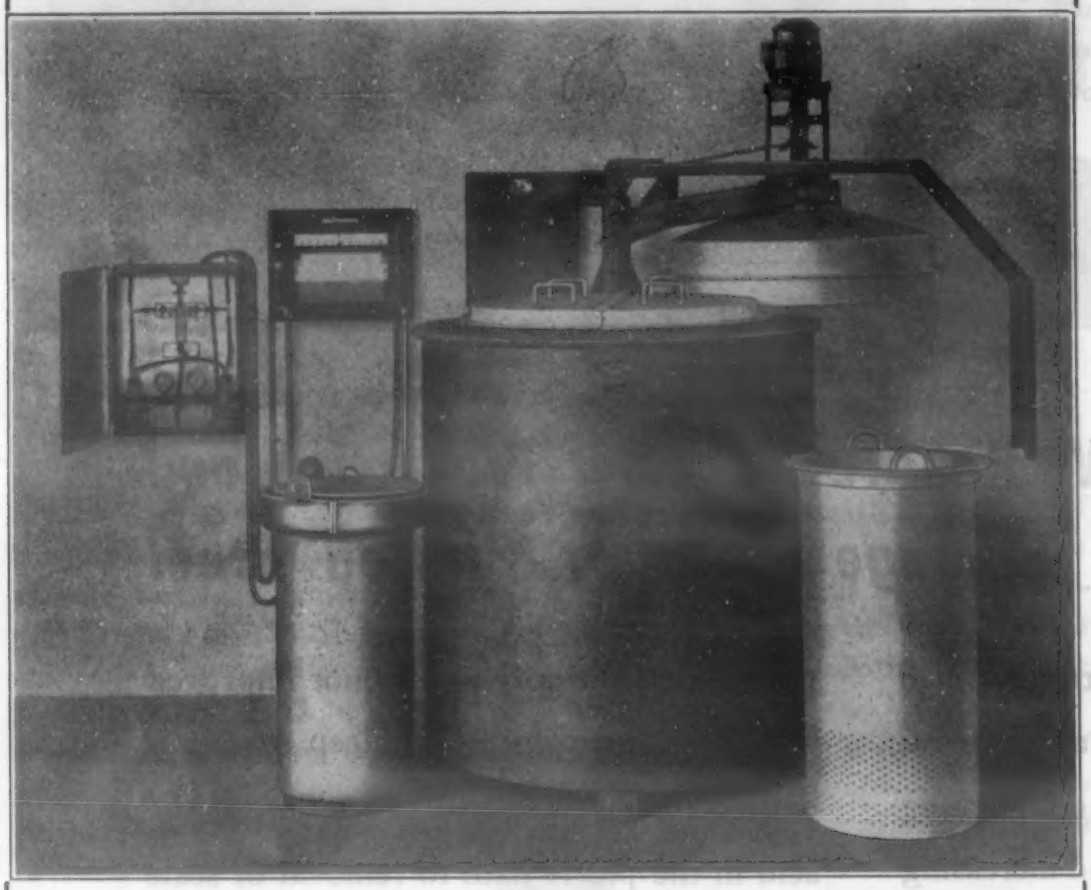

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photographic plate on which can be printed complicated designs in several colors, the first colors to be masked while the second and subsequent colors are applied.

—G. O. Taylor. *Can. Metals & Metallurgical Inds.*, Vol. 7, Nov. 1944, pp. 41-42.

Hydro-Piercing Steel Plates

Condensed from "Steel Processing"

Many parts in automobiles, jeeps, Army trucks, buses, and streamlined coaches are now being pierced hydraulically in special machines and fixtures. The fixture may stand anywhere, and in many cases it can be moved to the job. The time and expense saved by this method over drilling the same holes or piercing them in conventional press tools are very great.

Conventional presses cannot be used successfully or profitably for piercing of large awkwardly shaped pieces, where many of the holes must be pierced at diverse angles and from both sides, front and back, and top and bottom of the pieces. Hydraulic equipment can punch all the holes in one operation.

In the hydraulic piercing units, the punch-holder slide is reciprocated by the movement of a piston-rod attached to a piston head within the cylinder. The direction of travel of the punch holder is controlled by a four-way valve, which is operated either automatically by a solenoid coil, or manually. The valves are centered by springs.

One port is closed to the tank, and another port is opened to hydraulic pressure. The force applied against the piston-head moves the punch holder forward, and pierces the holes.

To return the piston, the valves are shifted, and the second port is opened to the tank, and hydraulic pressure is introduced through the first port. A special hydraulic oil refined for the purpose is used for operating the cylinders.

Hydraulic equipment is being used for piercing holes in radiator shells, stoker panels, fenders for trucks, rear body panels for attaching rear fenders, wheel-house panels, and door panels. In the last case, the hole for the lock handle is also coined and flanged in the same operation.

—C. W. Hinman. *Steel Processing*, Vol. 30, Nov. 1944, pp. 714-717.

Semi-Continuous Pickling of Strip

Condensed from "Metal Finishing"

Semi-continuous strip pickling is so named because each coil can be pushed through the line individually, eliminating the welder or stitcher, looping pits, and shear usually required for a continuous pickler.

Raw coils are placed by crane on a gently sloping ramp. A new coil is rolled onto

"A fine piece of mechanism" ... *says* LABORATORY USER.

This 225-ton Farquhar Hydraulic Press used in the processing of bricks at the College of Mines, University of Washington, is just one example of how Farquhar Hydraulic Presses render valuable service to industry.

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The major operation performed by the Farquhar Hydraulic Press, illustrated above, in the processing of bricks is to apply pressure, de-air and form the clay. The press has a capacity of 11,000 pounds per square inch on the side of the brick, or a total of 225 tons.

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In a KOLD-HOLD electrical refrigeration cabinet you can process metal parts and tools consistently at closely controlled temperatures as low as 150 deg. below zero—much lower than can be attained by the use of dry ice and the lowest temperature yet commercially available. This unit is especially designed for hardening steel tools, making expansion fits on close tolerance assemblies, for experimental work, and for product research.

These cabinets are built in two sizes, one having a work capacity of 5 cu. ft. and the other a capacity of 11 cu. ft.

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the coil box immediately after the tail end of the preceding coil has left the coil box, and is fed by hand onto a set of pinch rolls, which feed the strip into a leveller unit. The leveller removes the coil curvature and tends to break up the scale before the strip enters the first tank, containing hot water, which wets and heats the strip and removes loosened scale. The strip is then picked up by rubber-covered pinch rolls, which, in turn, feed the strip through the second tank, containing acid, and so on to the drier and recoiler.

The pickling chamber trough has a concave shape that supports the strip along the edges and exposes both the top and bottom surfaces to the acid, which is pumped through the trough in a direction opposite to that of the strip travel. This method of support prevents scratching of the strip surfaces.

All parts of the line are easily accessible. Efficient fume hoods are provided.

Operating costs are low, since four men constitute the entire crew. Installation and maintenance costs are low because of the type of construction and the use of a minimum number of mechanical units. This type of pickler has a definite application to small plants.

—C. F. Buente. *Metal Finishing*, Vol. 42, Sept. 1944, pp. 543-544, 546.

Metal Recovery by Anion Exchange

Condensed from
a Paper of the American Chemical Society

Details of a new process for recovering valuable and war essential metals were announced by Dr. Sidney Sussman, Dr. Frederick C. Nachod and William Wood, of the Permutit Company, New York.

Chromium, vanadium, molybdenum, gold, platinum, palladium, and other metals may be removed from waste solutions by absorption on anion exchange resins under given conditions. Thus, the new method introduces another new application for the anion exchange resins, members of the plastics family that have become widely used in one step of a heatless method for the low cost production of "distilled" water.

While primarily intended for the recovery of scarce and valuable metals now being lost in waste waters, the new method is also expected to be beneficial in reducing stream and harbor pollution in the vicinity of electroplating and other metal-working plants.

The resins to be used for the anion exchange are first exhausted with an acid, usually hydrochloric acid. The solution bearing the metal as a salt is then introduced, and is permitted to flow over the resin at a rate sufficiently slow to permit effective contact. The metal is held by the resin, and chloride ion is released.

Metal salts are absorbed even from very dilute solutions, and bound as metallic resinates. When complete absorption is no longer obtained, the resin is regenerated with an alkali, usually a sodium compound, and the metal is recovered as the sodium

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The production of control panels and aluminum shapes for airplanes received an impetus recently when Baldwin delivered one of the country's largest double acting flanging presses. Operated from a hydraulic pump and accumulator system, the inner and outer slides can be controlled separately or as a unit. Depending on the operation involved, pressure can be exerted from 1900 to 3300 TONS. A hydraulically operated sliding table is provided to insert and remove the heavy dies.

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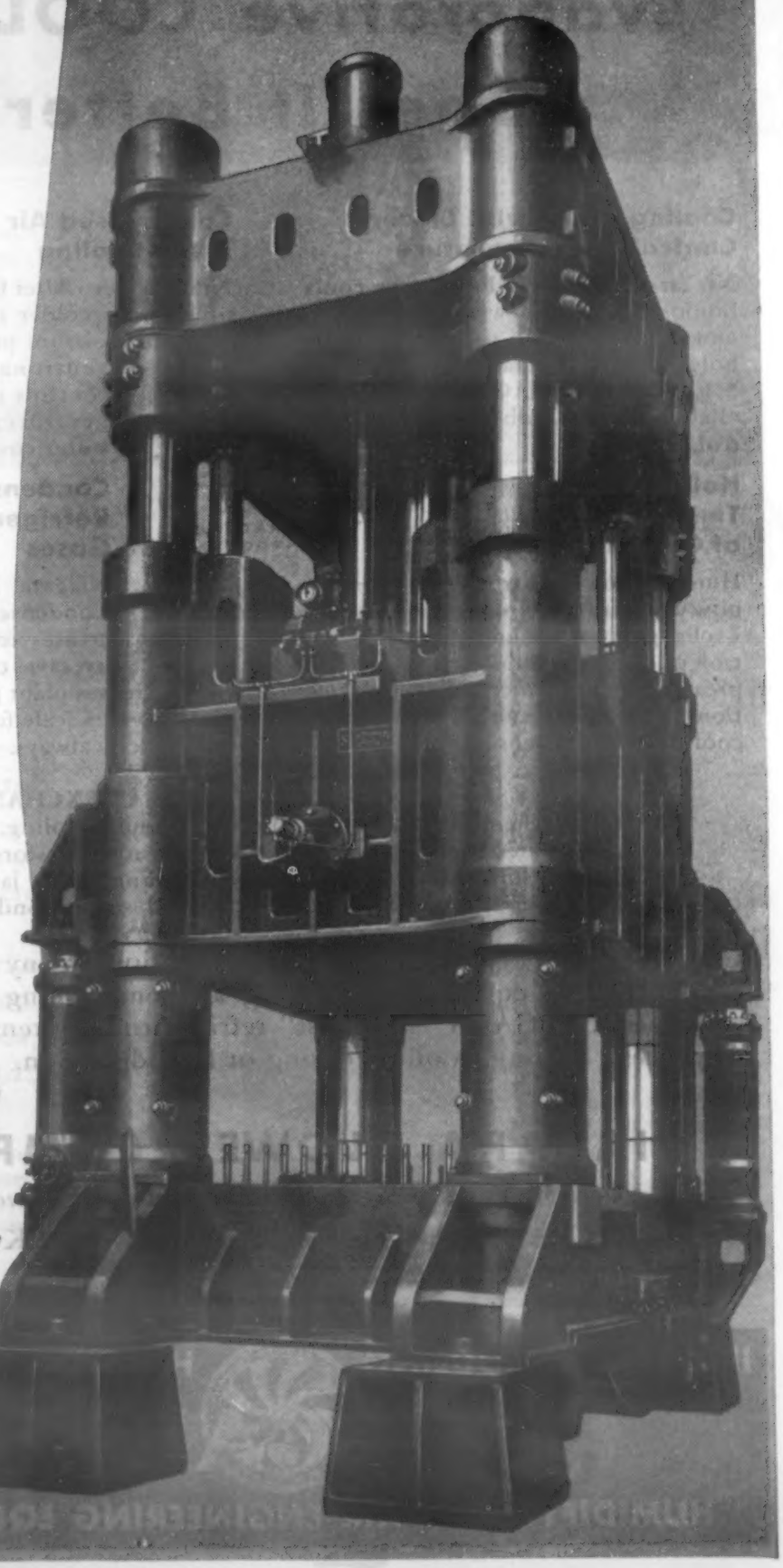

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salt of the formerly bound metal. By proper adjustment of the process, the final solutions may be 25 or 30 times as concentrated as the metal concentration in the original liquor.

In use with chromium plating solutions, it was found possible to recover a solution containing as much as 3% of sodium chromate. This liquor can be used to replace water in making up new plating solutions. The anion exchange resins undergo no permanent change in the process and may be re-used indefinitely.

In contrast to many previously proposed processes for the recovery of metals of this group, the new anion exchange process provides the recovered metal in the form of a salt that may be used directly in plating or other processes.

Because of the high prices they command, the precious metals, such as gold, platinum and palladium, may be recovered economically by the simpler alternate process of burning the anion exchange resin after saturation with the metal. Because the anion exchange resins are themselves almost entirely free from ash-forming impurities, the residue from this process consists of the practically pure metal.

—S. Sussman. Paper, *Am. Chemical Soc.*, December 1944 meeting.

Size Characteristics of Polishing Abrasives

Condensed from "Products Finishing"

Polishing abrasives must be carefully graded by particle size in order to perform satisfactorily. If an abrasive with a given grain size has a small proportion of particles excessively larger than the average, these particles will produce scratches in the work that are wider or deeper than the average. Such scratches may result in rejection of the work.

If the abrasive contains too many particles that are much smaller than the average, cutting action is slow and polishing costs are high. The necessity for a uniform grain in a given lot of powder is therefore apparent. Uniformity of particle size in different shipments is also obviously desirable.

Producers of electric furnace abrasives have spent much effort on methods for obtaining grain size uniformity. Accurate sieving machines have been developed for testing the uniformity of abrasives.

Silk has been found to be the best screen material, since the apertures do not tend to clog, as is the case with metal screens. Since the characteristics of the silk fibers vary with the humidity of the atmosphere, the testing is done in a room with controlled temperature and humidity.

As a result of the accurate testing with these machines, every shipment of abrasive can be guaranteed to be an exact duplicate of other lots of the same grade. Metal surfaces polished by these uniform abrasives show few "mountain peaks" when tested with a surface analyzer.

—Henry R. Power. *Products Finishing*, Vol. 9, Nov. 1944, pp. 66-68.

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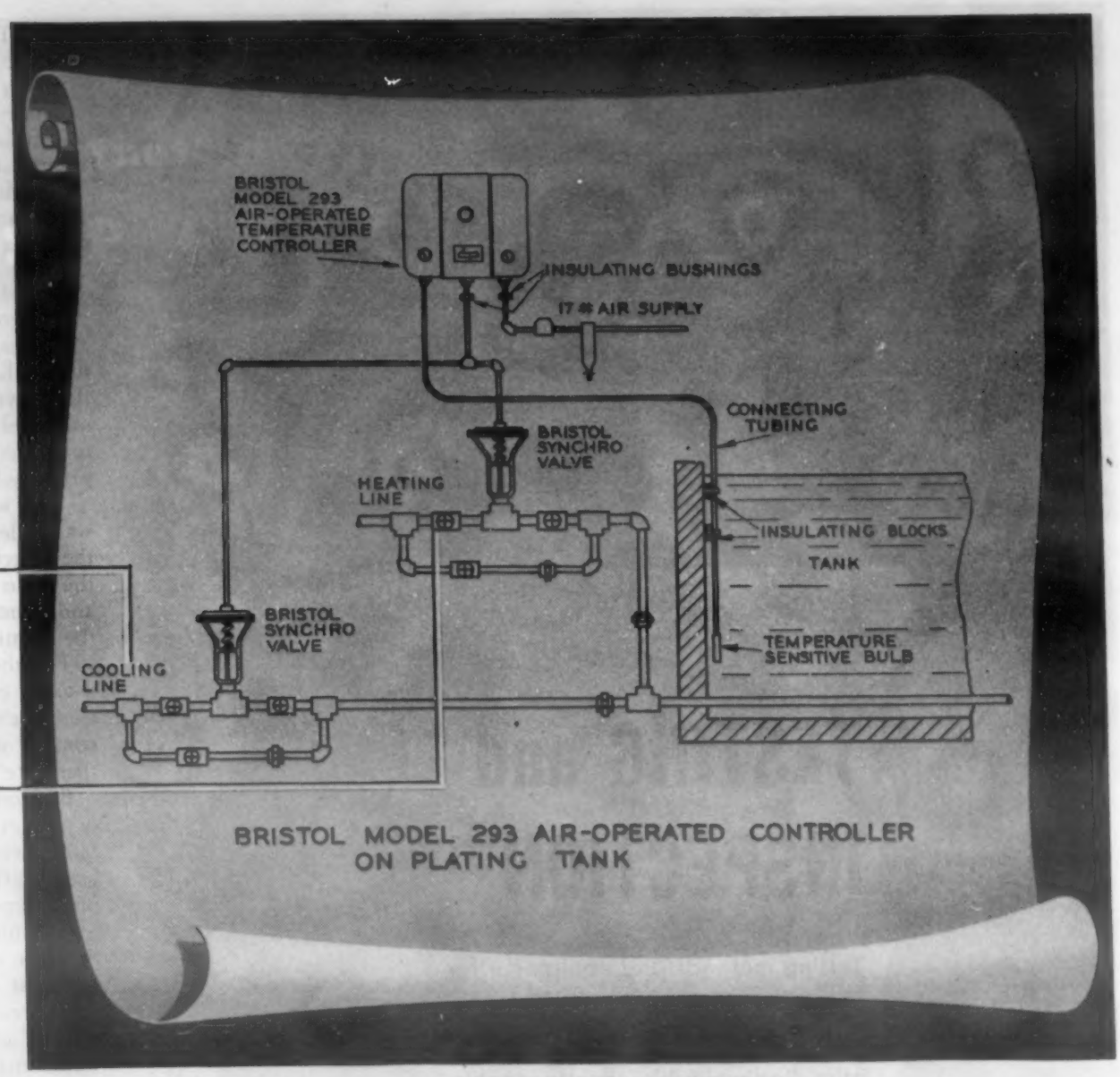

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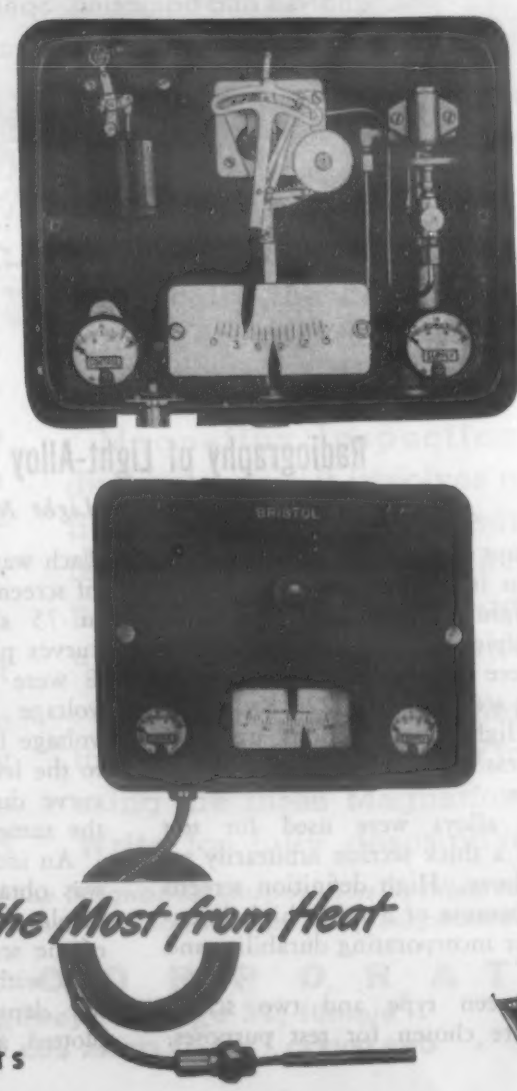
A new bulletin, No. A115, gives complete details. Write for a free copy to THE BRISTOL COMPANY, 162 Bristol Road, Waterbury 91, Conn. (The Bristol Co. of Canada, Ltd., Toronto, Ontario. Bristol's Instrument Co., Ltd., London, N.W. 10, England.)

Bristol's Model 93 Air-Operated Indicating Controller. Other Bristol instruments for these applications include recording air-operated controllers, electrically-operated (mercury contact) indicating or recording controllers, and open-contact indicating controllers. These Bristol instruments are described in Data Sheet No. 45.



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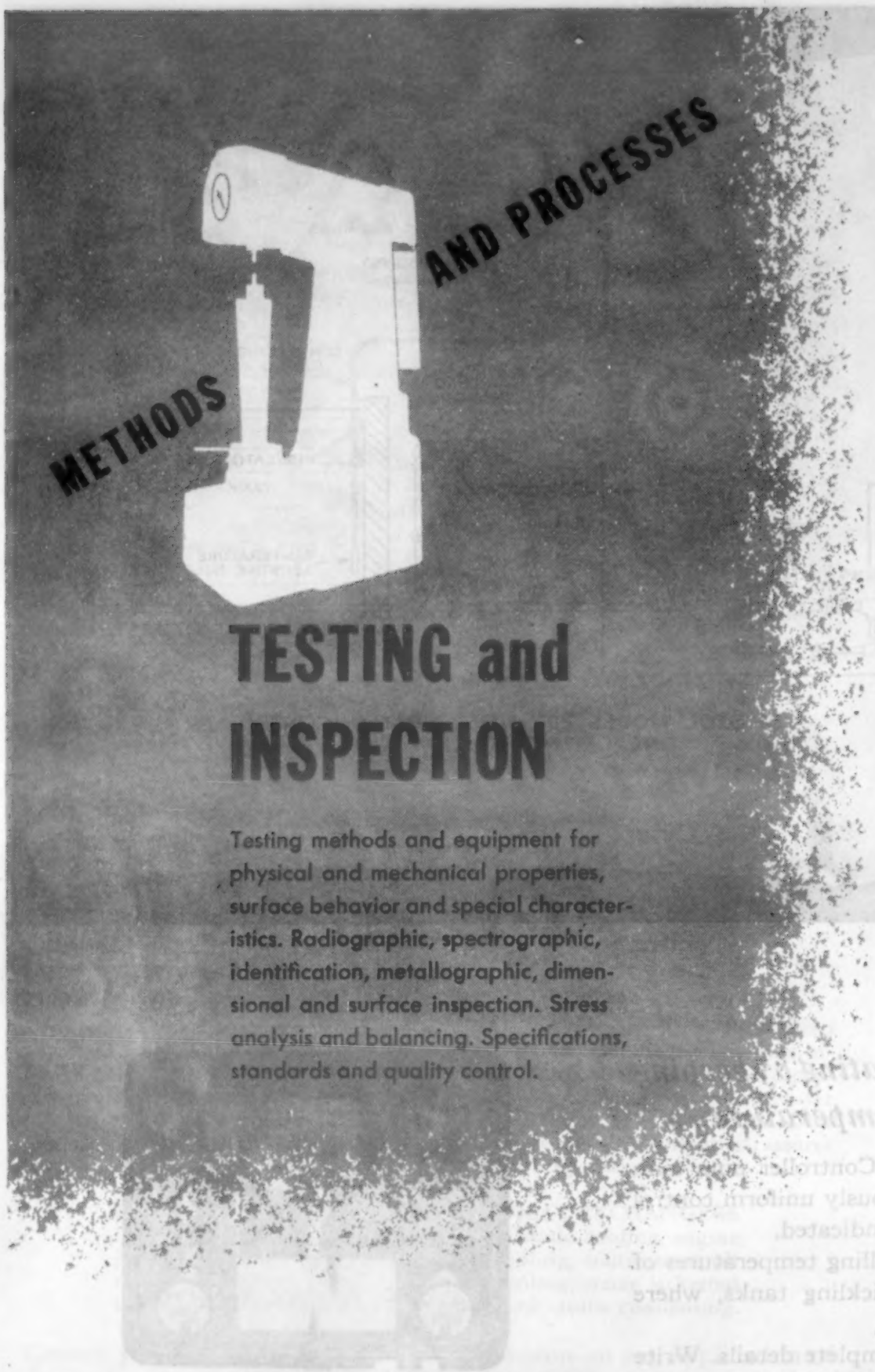
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Testing methods and equipment for physical and mechanical properties, surface behavior and special characteristics. Radiographic, spectrographic, identification, metallographic, dimensional and surface inspection. Stress analysis and balancing. Specifications, standards and quality control.

Radiography of Light-Alloy Castings

Condensed from "Light Metals"

In an attempt to make wider use of intensifying screens in the radiography of thick sections of light alloy castings, studies on films, intensifying screens scattering, and sensitivity were conducted. It was noted that by using screens and a 220 Kv. radiation source, light alloy sections up to 6 in. in thickness could be radiographed in 25 sec. or less.

Aluminum alloys were used for test purposes, and a thick section arbitrarily set as 3 in. or above. High definition screens were chosen because of a fairly high intensification factor incorporating durability and fine grain.

One non-screen type and two screen type films were chosen for test purposes. Each was exposed with and without the use of screens at kilovoltage steps of 25, starting at 75 and ending at 200. Characteristic curves plotting density against relative log E were drawn and grouped according to voltage used. It was noted that as the voltage increased the curves were displaced to the left, and the displacement of a given curve due to the use of screens was not the same for each voltage.

An indication of the intensification factor was obtained by measuring the horizontal displacement of a curve due to the action of the screens. As this value was found to vary with the density (becoming larger as the density increased), the values were plotted against Kv, keeping density constant. The above phenomenon indicates an increase in contrast due to the use of screens.

From the intensification factor—Kv curves—it was evident that in all cases a maximum intensification was produced around 160 Kv. These factors varied from 17 to 40 for screen-type film, and reached a maximum of about 3 for the non-screen film at a density of 1.0.

Types of Scatter

Specimen scatter was of three types: (1) characteristic radiation of the subject material, (2) unmodified radiation of similar wave length to the primary beam, (3) modified radiation produced by the Compton Effect of longer wave length than the primary beam.

The wave length of the modified beam was independent of the atomic number of the target and the subject element, although the ratio of the intensities of the modified and unmodified beam varied according to the atomic number of the scattering element.

For the alloys used this latter ratio had a value of about two to one. In the direction of the primary beam the modified beam consists of its longest wavelengths, and is therefore most easily absorbed.

Suggested methods of reducing the effects of scatter are: (1) filter of the tube, (2) filter between subject and film, (3) the use of grids, and (4) the use of intensifying screen.

Arguments and experiments concerning the first two methods are as follows: (1) Filter at the tube reduces, at the source, the intensities of the longer, principal scatter-producing-wavelengths, although some scatter may still be produced in the subject, which must be dealt with by other means. This latter scattering is often the most important. (2) Filter between film and subject increases subject-film distances, which reduces sensitivity unless the source-subject distance is increased.

(3) Filter between the film and subject must be uniform and defect-free, which requires careful and specialized handling. (4) The use of filter effectively increases the subject thickness, which necessarily reduces the sensitivity of the resulting radiograph, neglecting scattering.

Test Results

One-inch lead squares 1/6-in. in thickness were placed on the top and bottom of a 6-in. thickness of aluminum alloy, and the unit radiographed. The marker beneath the subject was clearly visible as it stopped all radiation. The top marker was indistinct because radiation was scattered in from the sides, although all the primary radiation was stopped.

The experiment was repeated using the 0.04 in. of copper sheet first at the tube and then between the subject and film. Little difference was noted in the last two cases, although there was considerable improvement over the radiograph produced with no filter at all.

A limited number of filter materials was tried and copper sheet proved to be the most successful. The 0.04-in. copper filter was then equally split and half used in each position. This technique showed a slight decrease in the effect of scattering over any method tried to that point.

Ionization chamber measurements of the primary beam after it had penetrated a

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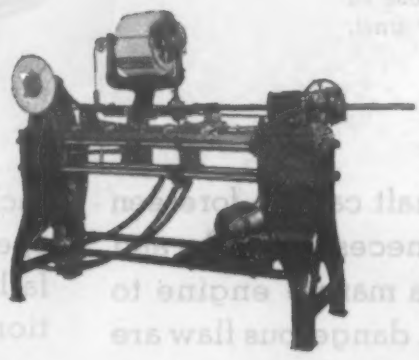

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5-in. thickness of aluminum alloy showed a minimum intensity when the 0.04-in. copper sheet was placed between the chamber and the alloy as against placing the sheet between the alloy and tube. This showed a marked difference in the beam as the order of materials penetrated by it was varied. Some scatter was still getting through, as was shown by the difference in image densities of the two squares.

Use of Grids

The introduction of a grid, such as the Bucky-Potter type, between the subject and film removes a large portion of the scattered radiation incident to the film at angles other than that of the primary beam. It is to be remembered that using such a grid increases subject film distance and so reduces maximum sensitivity unless other steps are taken.

The fourth method of reducing the effects of scatter is the use of intensifying screens. It has been pointed out that the largest intensification is experienced with a beam generated at 160 Kv. If such a beam is used, the scattered radiation, being of longer wavelength, will be intensified to a lesser degree than the primary radiation, and an overall improvement will result as was confirmed by test.

As none of these four methods of reducing scatter and its effect interfered with each other, all can be used together. The grid produced a negligible effect when used in conjunction with the other three methods. This showed that the divided filter and screens reduced the photographic effect of much of the scatter to a minimum, and that grids could be eliminated.

Sensitivity Factors

So far the objective has been to reduce the effect of scatter without considering the sensitivity of the final radiograph. Factors governing sensitivity are:

(1) The effective tube target area. In most cases this is fixed and for the purposes at hand may be neglected.

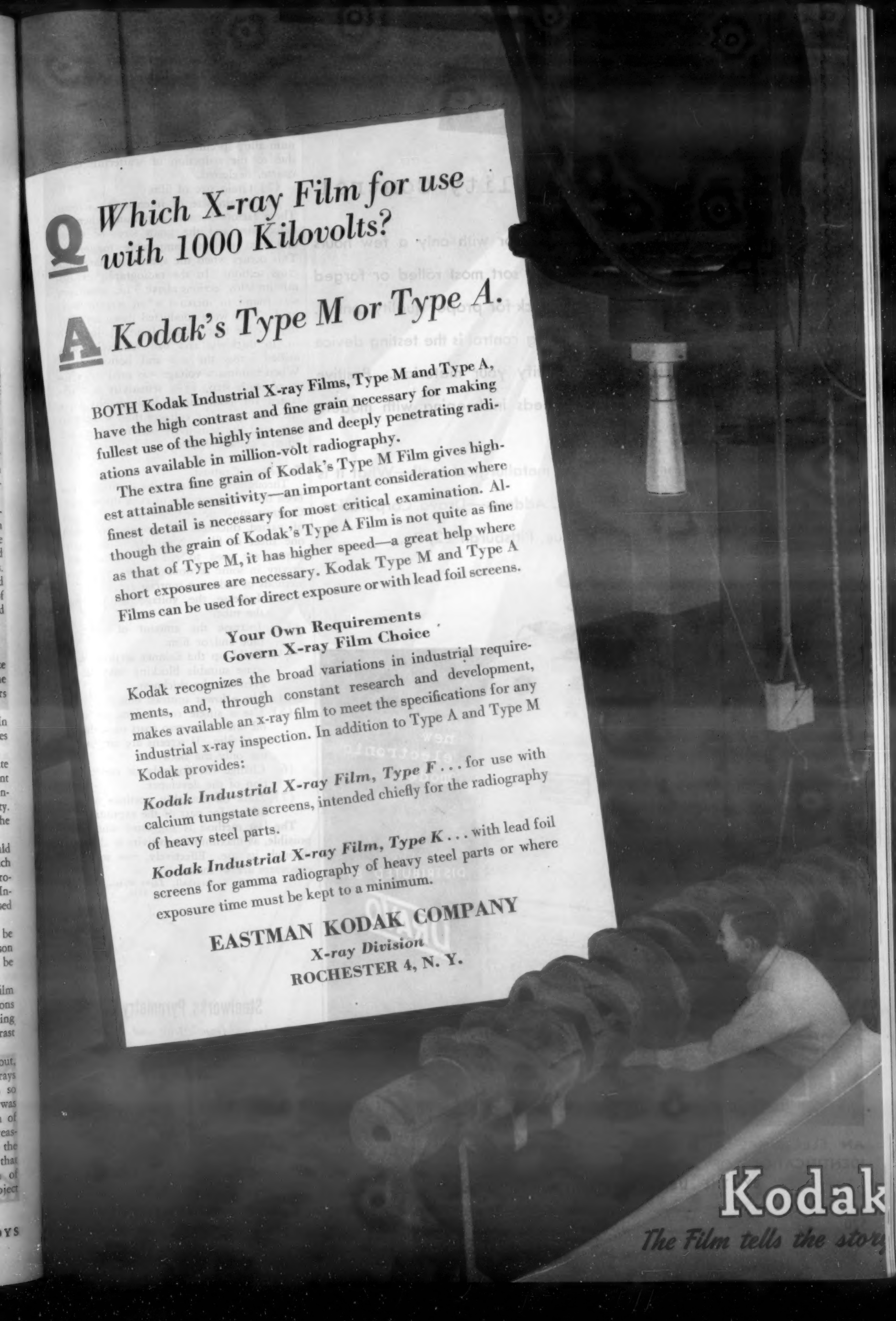
(2) The kilovoltages used to generate the X-radiation. It is the most important consideration and should be kept at a minimum to produce the maximum sensitivity. As the applied kilovoltage increases the photographic contrast decreases.

(3) The object-tube distance. It should be kept at a maximum and still be of such magnitude that radiographs may be produced in a reasonable interval of time. Increased tube distance results in decreased penumbrial effect of defects.

(4) The object-film distance must be kept at a minimum for the same reason that the object-tube distance should be large.

(5) The nature of the film. The film should be of such character that all portions of the radiograph fall within the working range of the film. Latitude and contrast are implied.

(6) Filtration. As has been pointed out, the long wavelength contrast-producing rays are reduced in intensity by the filters so that photographic contrast is lost. It was also stated previously that the addition of filters has the detrimental effect of increasing the object size and thereby reduces the specimen sensitiveness. It was shown that with 120 Kv. radiation, the addition of 0.04-in. copper filter increases the object



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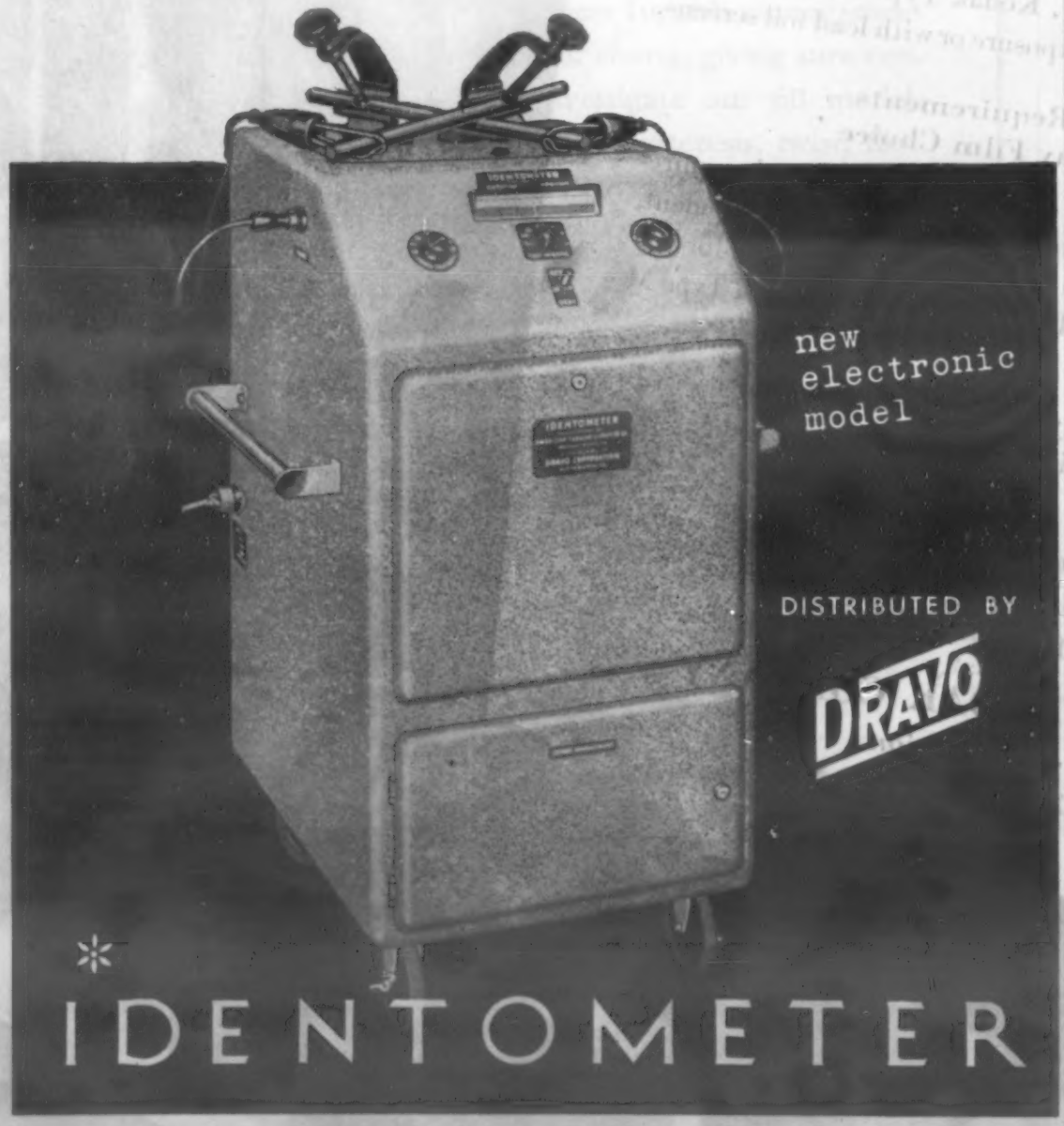

* IDENTOMETER

AN ELECTRICAL INSTRUMENT FOR THE INSTANT AND ACCURATE IDENTIFICATION OF MOST ROLLED OR FORGED FERROUS ALLOYS BY THE USE OF REFERENCE SPECIMENS

thickness of a 2-in. aluminum alloy specimen to 2.56 in. If a radiograph is produced to show 2% object sensitivity, the smallest defect visible would be 0.0512 in. as against 0.040 in., a 2% defect in the 2-in. aluminum alloy specimen. Increase in sensitivity due to the reduction of scattering is, of course, neglected.

(7) Grain size of film.

(8) Grain size of intensifying screens. These factors become important when the defect size and the grain sizes of screen and film are of comparable magnitude. This occurs when the specimens have thin cross sections. In the radiography of aluminum alloy sections above 3 in., sensitivity was found to increase when screens were used. Tests were conducted using an alloy step wedge that ranged from ¼ in. to 6 in. in thickness and had sensitivity slots milled across the top and bottom faces. When minimum voltage was used to radiograph each step, ½% sensitivity was obtained for both faces. Radiographs were taken using higher voltages than was necessary, and the sensitivity was found to fall off to a marked degree.

To Reduce Contrast

Throughout the paper the discussion has been limited to subjects of even thicknesses. Contrast must be reduced when a subject of varied thickness is radiographed with one sheet of film. Naturally, when techniques are used to reduce contrast, sensitivity in some sections is lost. Suggested methods of reducing contrast are:

(1) Increase the voltage drop across the tube.

(2) Increase the amount of filter at tube and/or film.

(3) Build up the thinner sections with some suitable blocking material to even out the thickness.

(4) Use a lower contrast film.

(5) Use a single coated film, or strip off one of the two coats on a duplitized film. If screens are employed, use only the back one.

(6) Change the formula or concentration of the developer.

(7) Mask off the thin portions of the subject for part of the exposure.

The last method is suggested whenever possible, as maximum sensitivity is claimed through its use. Effectively, two separate exposures are so made.

—C. T. Snushall. *Light Metals*, Vol. 7, Aug. 1944, pp. 375-382.

Steelworks Pyrometry

Condensed from "Iron and Steel"

Radiation and optical pyrometers that are of the non-contact type are used for dealing with inaccessible and very hot bodies. Radiation pyrometers are suitable for 932 F. upwards, and optical pyrometers for 1382 F. upwards.

Operation of these pyrometers depends upon the principle of radiant energy. The instruments are, in effect, receivers of radi-

(Continued on page 524)

VISUAL INSPECTION of INTERNAL SURFACES with POLAN BORESCOPES

For work in which the inspection of internal surfaces is a factor, Polan Borescopes give detailed. minute inspection.

Requiring no special operator training, Polan Borescopes are practical in usage. Designed for inspection of gun bores, bored engine shafts, cylinders, etc., with absence of eye fatigue. Efficient inspection of bore diameters ranging from 20mm to 9 inches; lengths up to 30 feet.

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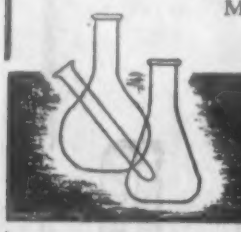
Write for Bulletin MA 2-45



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The Eberbach tester is equipped with an indenter unit designed to mount on any metallurgical type microscope. An accurately ground diamond indenter permits measurement directly in diamond pyramid units, instantly convertible to other systems. Data may be taken visually or photographically.

Write for complete information.

Eberbach & Son Company

ANN ARBOR, MICH.

LABORATORY APPARATUS & SUPPLIES

ESTABLISHED 1843

ant energy from a hot body, and their function is to translate the energy received into terms of temperature.

Increasing the temperature of a body causes increase in rate of radiation of energy from it. This rate is independent of the medium surrounding the body, and can take place through a vacuum. On the other hand, it is greatly affected by the material, surface, and physical characteristics of the body emitting the radiation, and, therefore, all the laws relating to temperature and radiation are based on the assumption that the body under consideration is a radiator having 100% efficiency. This is called "black body" radiation.

Black body radiation is emitted by a perfect radiator. Such condition cannot be obtained with a body in the open, but the ideal can be approximated by an enclosure at a uniform temperature radiating through a small aperture. When enclosure is cold and is viewed through a peep-hole, whatever the color of its interior surface, and of the bodies contained within it, there will be an entire absence of color, *i.e.*, the impression of blackness will be obtained.

Elements of a Pyrometer

Essentially, a total radiation pyrometer is a black body. Depending upon its temperature, the pyrometer will also radiate energy, but this may be neglected. Therefore, the energy received by the pyrometer is directly proportional to the absolute temperature of the hot body raised to the fourth power.

A pyrometer is cylindrical and open to radiation at one end; the other end contains a temperature-sensitive element upon which radiant energy is directed. The first essential of a receiver is that its radiation-receiving surface has no powers of reflection. Secondly, equilibrium of interchange of energy between the temperature-sensitive element, its surroundings, and hot body should be attained as soon as possible.

The simplest form of radiation pyrometer is the Féry fixed focus mirror type. The open end is provided with a diaphragm with an aperture, while the closed end contains a concave mirror with a small temperature-sensitive element situated at its focus. Radiant energy entering the tube is reflected by the mirror on this element. Theoretically, the image formed at the mirror focus will be that of all the energy of all wave-lengths both visible and invisible.

Intensity of the radiation received and reflected is independent of the distance of the pyrometer from the hot body, provided the aperture of diaphragm is completely filled by the radiation. The ratio of the distance of the hot body from the pyrometer is known as the distance factor.

The temperature-sensitive element consists of the hot junction of a small thermocouple, which generates an electromotive force in proportion to the difference in temperature between hot and cold junctions. The hot junction may be attached to a thin plate. In some instruments a number of small thermocouples are used, connected in series to form a thermopile.

Pyrometers using a lens system are shorter than mirror type but of greater diameter. In the fixed-focus type, radiant energy is focused on the receiving disc through a double convex lens.

Now Available **FOR THE FIRST TIME**

AIR OPERATED SEMI-AUTOMATIC SPECIMEN MOUNTING PRESS

FREES OPERATOR FOR OTHER DUTIES. NO EFFORT REQUIRED FOR OPERATION. COMPLETELY ELIMINATES HAND OPERATED HYDRAULIC JACK.

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for simplified specimen mounting. Using air for operation this modern mounting press produces uniform specimens, identical in size and hardness, without attention of skilled operator and in a fraction of time used by other mounting presses. Complete operation of placing molding powder in die, locking head in place, applying air pressure to cylinder requires less than a minute. No further attention is required until curing is completed. This frees the operator for other duties and affords a considerable savings in time. This feature alone will pay for this equipment in a very short time.

FEATURES

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2. Does not require operator's continuous attention, as only approximately 1 minute is required to load the machine and place it in operation. No further attention until curing is completed.
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✓ Direct deflection construction permits instantaneous readings in either millivolts or temperatures.

✓ A sturdy carrying case with removable cover is the complete unit providing convenient portability.

Scale length of indicator is 6″, which may be calibrated with 100 to 150 divisions. Scale range may be selected to suit particular applications. All indicators are equipped with Engelhard frictionless moving coils.

Model P-2 (shown above) can be furnished calibrated with two scales for rare metal and base metal thermocouples. Connections are plainly marked on indicator so that correct readings are obtained on either scale range.

For further information, write for Bulletin 28315-R!

CHARLES ENGELHARD, INCORPORATED

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Allowance for Variables

Water vapor, dust and furnace gases cut off infra-red rays, and, therefore, due allowance must be made for these factors. Observations through flames may have a considerable and variable effect on pyrometer readings.

The most difficult cases to deal with are molten metal temperature measurements in the open, owing to clouding by oxidation. Taking the case of molten iron, when the surface is clear, 35% should be added to observed reading. When the surface is oxidized, correction is reduced to about 5%. The latter figure is approximately correct for oxides of all metals.

Optical pyrometers respond instantaneously to temperature variations, and are independent of the working distance. They are only suitable for isolated readings, although recording optical pyrometers have been developed.

Since brightness and color cannot be measured by eye, an optical pyrometer is not an absolute type of instrument but a comparator. Therefore, it is a telescope with a suitable optical system through which hot body is viewed and compared with the light intensity from a standard source of illumination. Observation is limited to one wave length by viewing the body and the standard source through a monochromatic screen.

Disappearing Filament Type

The most familiar form of optical pyrometer is of the disappearing filament type. The filament of a standard electric lamp is first focused. The instrument is then directed towards the hot body and the image of a small portion is focused in the same plane as the lamp filament. A rheostat is adjusted until brightness of the lamp filament matches that of the source, which is obtained when the filament becomes invisible.

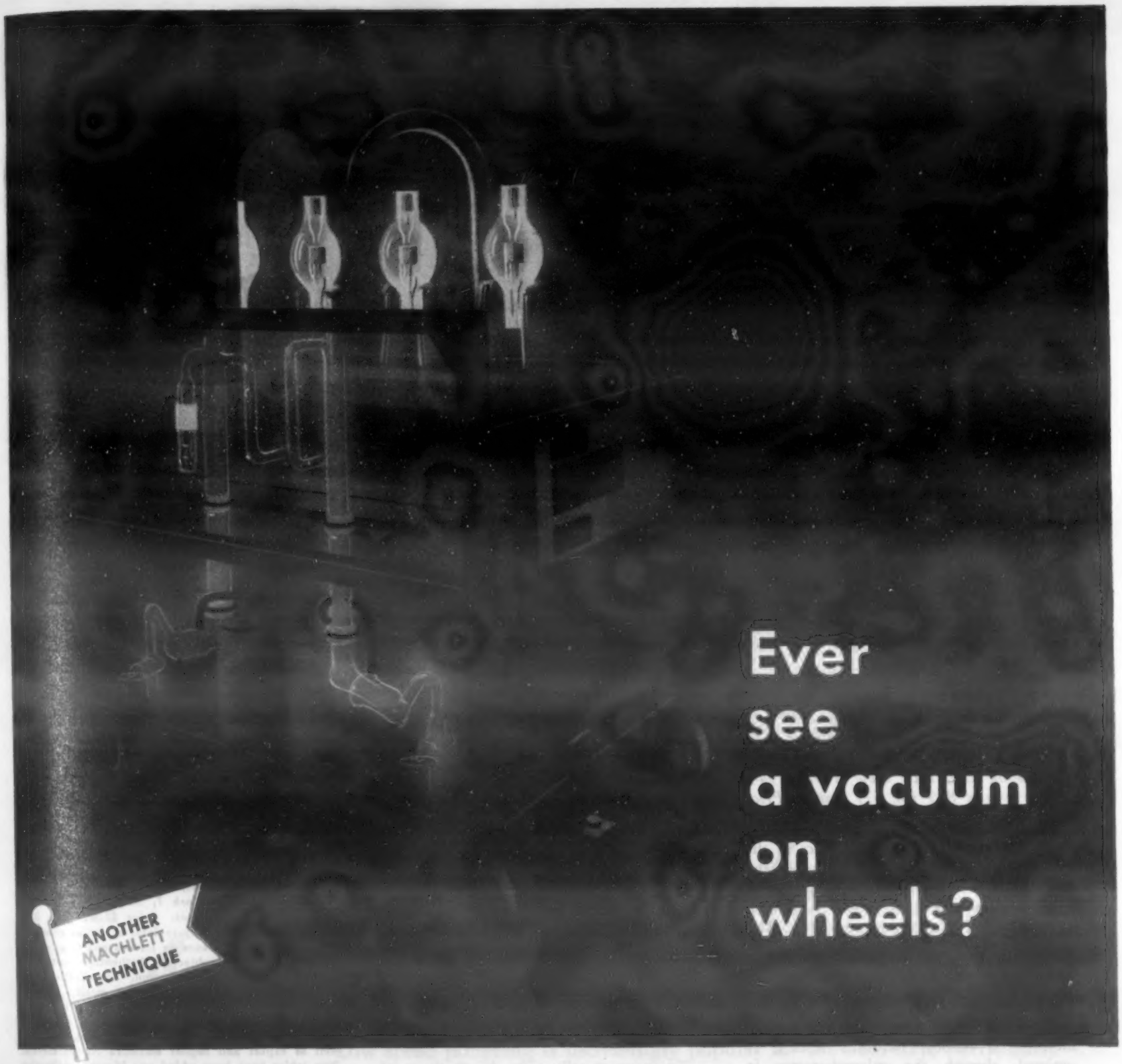
In another pyrometer, both sources of heat and standard lamp are viewed through a monochromatic screen, but rays from the hot body are polarized in one plane and rays from the lamp in a plane at right angles. Two beams are then passed through a Nicol prism. By rotating the Nicol prism, the brightness of one field is increased and that of the other decreased, the position of Nicol prism when both fields are equally illuminated being a measure of temperature.

In certain optical pyrometers the extinction of the luminous flux by a wedge-shaped dark glass located between objective glass and standard lamp is inside. A prism is moved into the field of vision, thereby increasing the thickness of the glass, until the hot body disappears from view. Position of the wedge is noted on the scale, which is graduated in temperature units.

A recent development is a two-color-type pyrometer in which photoelectric cells are used to obtain the required ratio. By means of reflectors and green and red screens, green rays are reflected onto one cell and red rays to the other.

The effect on the conductances of the cells determines current flow through each, and outputs are balanced by adjusting resistances, magnitude of adjustment being a measure of temperature.

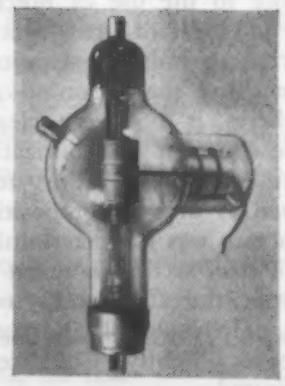
—A. Linford, *Iron & Steel*, Vol. 17, Oct. 1944, pp. 632-636; Nov. 1944, pp. 671-675.



The final stages of manufacture of X-ray and other electronic tubes must include thorough "outgassing" to remove gases held within the metal tube parts, as well as the gas inside the glass envelope. This has customarily been done in three separate operations, and it was considered inevitable for two-thirds of the equipment to be idle while one-third was in operation. Machlett felt that this produced highly undesirable effects on output, costs, and on tube quality.

So we developed a unique production line. The tubes are sealed on a high-vacuum pump which is mounted on a dolly, and thus can be wheeled through each operation, while pumping continues steadily. The dolly goes first to a baking oven (shown above); then to a station in which the tube elements are heated red hot by induction; finally they are bombarded repeatedly at 70,000 volts. This is about 10 times the usual voltage, and not only reduces the time required in a later seasoning process, but assures much better tubes.

The system approximately triples the output of the equipment. That alone was invaluable in meeting tremendous war orders. But we also believe that it produces tubes with less residual gas and hence improved operation and longer life. When buying X-ray tubes for medical, dental, scientific or industrial purposes, or radio tubes for communications or industry, remember this Machlett technique which makes possible the production of the tube shown above . . . Machlett Laboratories, Inc., Springdale, Connecticut.



ML-861, screen-grid r-f oscillator and amplifier tube.

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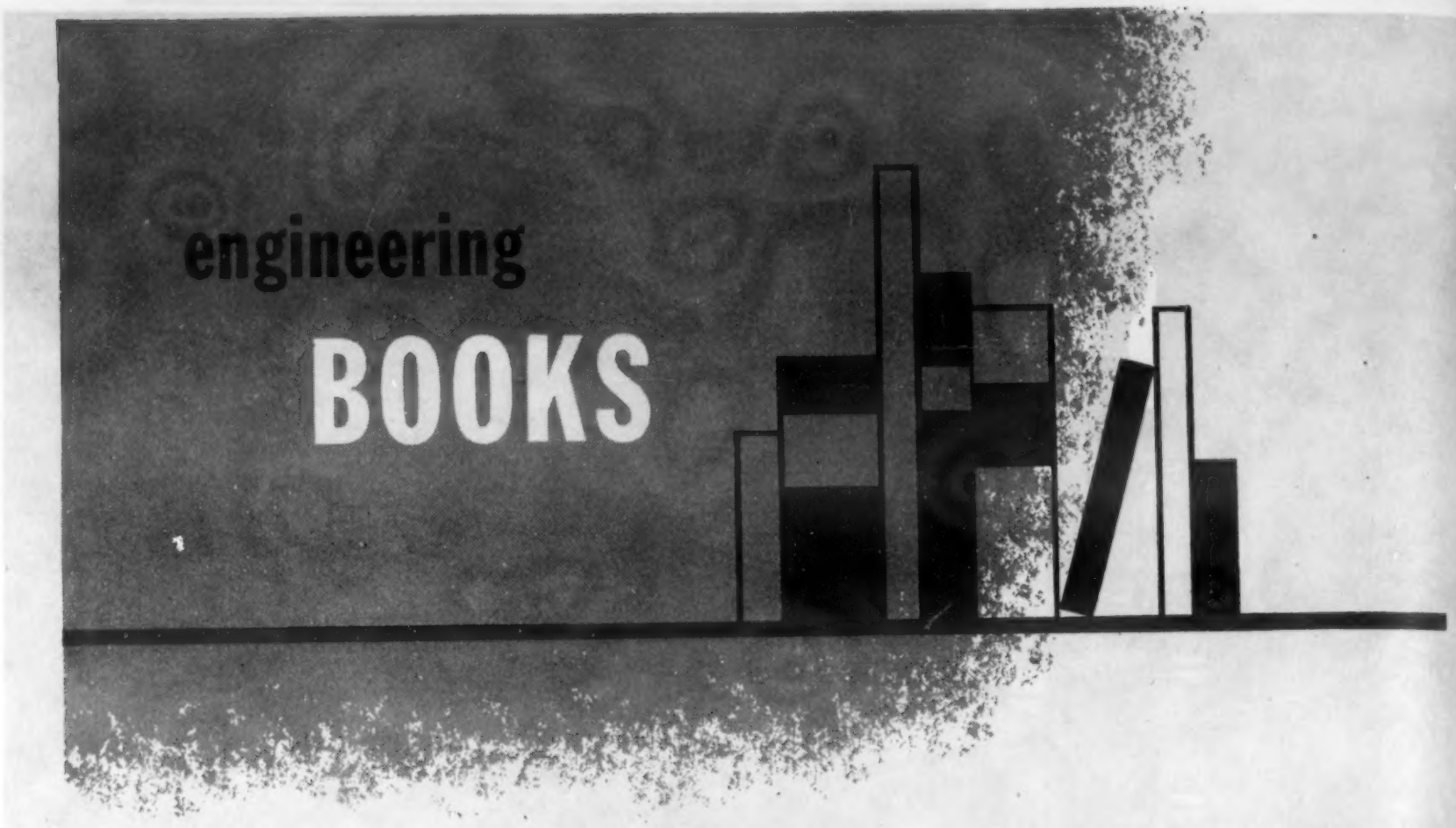


Ferrous Metallurgy

FERROUS METALLURGY. VOL. III—METALLOGRAPHY AND HEAT-TREATMENT OF STEEL. *Second Edition. By Ernest J. Teichert. Published by Mc-Graw-Hill Book Co., Inc., New York, 1944. Cloth, 5½ x 8½ in., 577 pages. Price $5.00.*

This deals with the usual topics in the usual way. It is designed for use in the Penn State extension courses, for which some parts would seem rather hard reading. Nor is it particularly up-to-date. The blurb on the jacket says that special attention is given to the N. E. steels. Actually, they get just one page, which succeeds only in saying that they exist.

Induction and flame hardening are not mentioned; Knoop hardness testing is omitted, though the microcharacter is dealt with; fatigue testing is described without reference to the use of notched specimens, and the topic of stress concentration is referred to only in respect to cracking on quenching; the section on controlled atmospheres is not very clearly written, and the effects of decarburization are not sufficiently stressed. Alloy steels are still discussed as though composition rather than structure was the determining factor. The tool steel section is taken almost bodily from the Carpenter handbook, and the molybdenum high speeds are passed over very lightly. Cold treatment is not discussed.

The mild alloy steels are dismissed with the bare mention of a couple of the members of the family. On page 85 low temperature impact of a temperature-sensitive steel is stated in the text as "no more than 90%" of its room temperature value, when the table shows 10%. On page 466 comes the statement that "increased machinability may be obtained by addition of 0.00 to 0.30% S or Se." Doing it with 0.00 is quite a trick.

Most of the material given is correct and useful, and the book is usable. It is, however, disappointing that a "new second edition" should not stand out among the dozen similar books of fairly recent vintage. Except for half a page on martempering, everything in it can be found in earlier books.

—H. W. GILLETT

Ternary Phase Diagrams

TERNARY SYSTEMS. Introduction to the Theory of Three Component Systems. *By G. Masing. Translated by B. A. Rogers. Published by Reinhold Publishing Corp., New York, 1944. Cloth, 6¼ x 9¼ in., 173 pages. Price $4.50.*

To many metallurgists this "primer of ternary phase diagrams" will need no recommendation, for the original edition (in German) has been widely circulated and read in the English speaking countries. It is a pleasure to be able to report that the translation is excellent, both the substance and spirit of the original text being faithfully preserved in simple but precise English.

Despite its imposing title, the book is designed to place before the beginner a lucid introduction to the structure and interpretation of ternary phase diagrams. Ideal, rather than real, alloy systems are used for the explanations. A large number of excellent drawings serve to amplify the text; these are, for the most part, well reproduced in the translation.

Individual chapters are devoted to the "Thermodynamic Fundamentals" and to each of the basic configurations found in ternary alloy diagrams. The last three chapters deal with the alloy systems Fe-Si-Al, Sn-Zn-Cu and Fe-C-Si, respectively. Apart from this, no attempt is made to catalogue the existing constitutional data on ternary alloy systems.

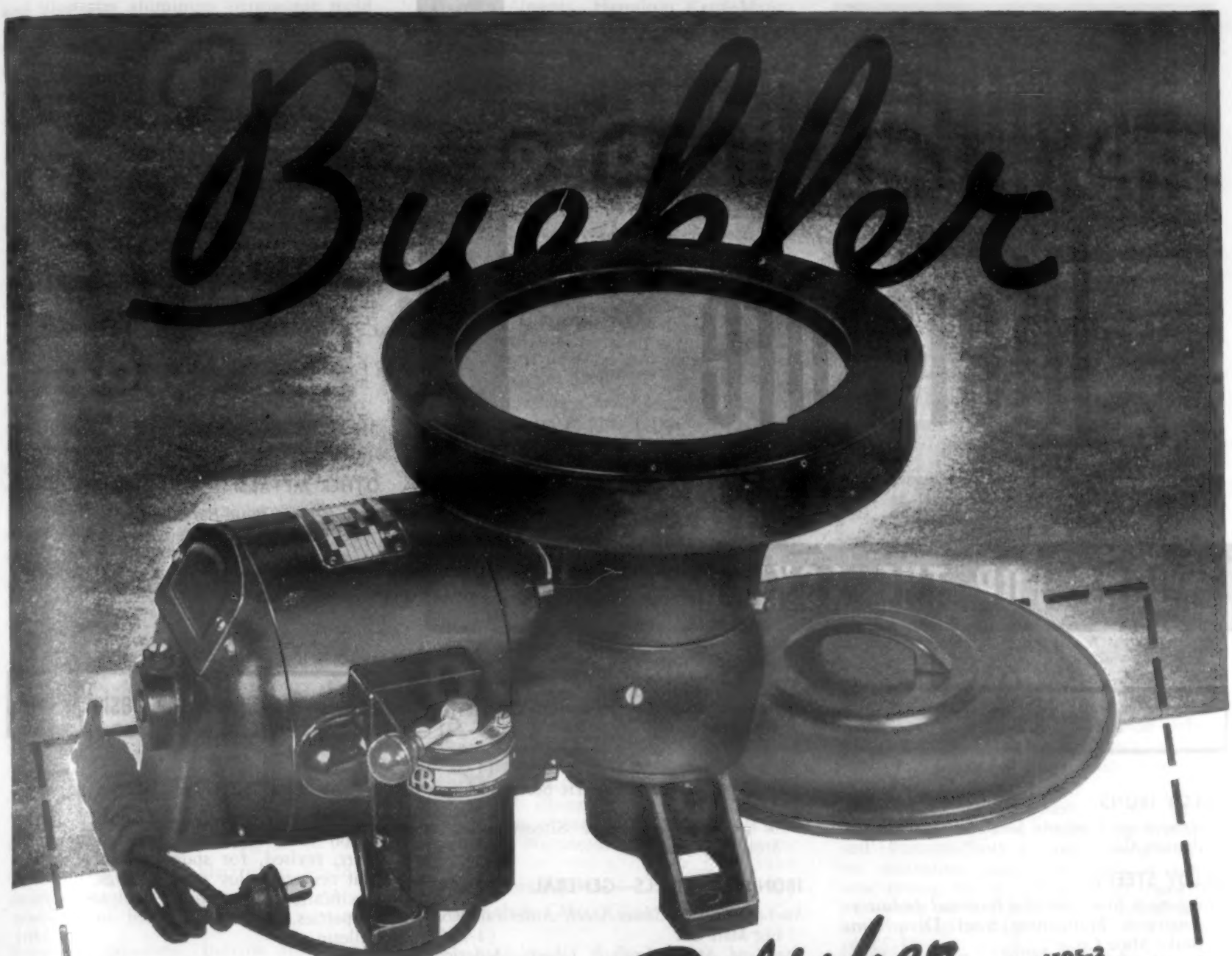
As a key to the intelligent use of ternary phase diagrams, this book deserves a place in every library on physical metallurgy.

—FREDERICK N. RHINES

Other New Books

METAL STATISTICS—1944. *Published by American Metal Market, New York 7, N. Y., 1944. Cloth, 4¼ x 6¼ in., 768 pages. Price $2.00.* This 37th annual edition brings up-to-date, so far as possible, the data in former issues on ferrous and non-ferrous metals and other subjects. Authentic, up-to-date figures on domestic production, consumption and stocks of the leading non-ferrous metals, banned early in 1942, are again available and are included. The same situation does not prevail on such critical items as tin, manganese, platinum, etc., as well as export and import statistics on all metals. New tables have been added on: Monthly deliveries of fabricated aluminum products, consumption of mercury by uses, a comparison of the mines and smelter production of zinc, and so on.

MANUAL OF A.S.T.M. STANDARDS OF REFRACTORY MATERIALS. *Published by the American Society for Testing Materials, Philadelphia, Pa., 1943. Paper, 6 x 9 in., 201 pages. Price $1.50 for paper cover; $1.75 for cloth.* The latest manual of A.S.T.M. Standards on Refractory Materials, with other pertinent information and data, is the fifth sponsored by A.S.T.M. Committee C-8 on Refractories. It includes new standards for air setting refractory mortars, fireclay plastic refractories both for boiler and incinerator services, methods of test for measuring the shrinkage, spalling and workability index of fireclay plastic refractories, and a method for measuring the thermal conductivity of insulating fire brick. Seven specifications on refractories for various types of service are given. An important part is a group of industrial surveys, which are a most important contribution to the literature in this field. These surveys describe the operations carried out in the furnaces, the types of refractories used in them, and outline the conditions that affect the life of the refractories. A list follows: Open-Hearth Practice; Electric Furnaces Used in Steel Manufacture; Malleable Iron Industry; Copper Industry; Lead Industry; By-Product Coke Ovens; Lime Burning Industry; Glass Industry; Portland Cement Industry; Stationary Steam Boilers. Other data in the manual cover standard samples of refractory materials for chemical analysis, and for pyrometric cone equivalent.



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3. Engineering Design

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Bearings. Timken Roller Bearing Co. The mounting of the spindles of hydraulic surface grinders on tapered roller bearings, thus assuring smooth spindle operation, maximum spindle rigidity, etc., is described and illustrated in a single sheet. (3-528)

Wire Staples. E. H. Titchener & Co. All types and sizes of wire staples are described and illustrated in a 4-page bulletin (3-525)

Ball Reciprocating Bearings. Torrington Co., Bantam Bearings Div. A complete list of recommended sizes of high-capacity ball reciprocating bearings is presented in a revised bulletin, No. 105. (3-536)

Eyelets, Ferrules, Etc. Waterbury Companies, Inc. Complete technical data on a variety of eyelets, ferrules, terminals and metal parts are presented in a 26-page, illustrated bulletin. (3-534)

Flexible Metal Hose. Chicago Metal Hose Corp. (3-515)

Gears. Fairfield Manufacturing Co. (3-514)

Magnet Wire. General Electric Co. (3-284)

Electrical Contacts. Gibson Electric Co. (3-76)

Magnet Manufacture. Indiana Steel Products Co. (3-359)

Brush Springs. Instrument Specialties Co. (3-451)

Porous Bronze Bearings. Keystone Carbon Co. (3-331)

Wear Resistant Precious Metal Parts. Permo, Inc. (3-65)

NON-METALLICS

Plastics. General Electric Co. An attractive, 24-page bulletin, No. PH-518, presents complete design data on plastics for product designers, and includes numerous illustrations and tables on general properties, physical properties, etc. (3-523)

Plastics, Resins, Varnishes. Hercules Powder Co. A complete list of this company's plastics and related chemicals, and the 50 industries which they serve, is presented in an attractively illustrated, 36-page bulletin. (3-535)

Cellular Rubber. Sponge Rubber Products Co. Sponge and Cell-Tite cellular rubber products, available in sheets, strips, tubing, etc., are described and illustrated in a 4-page bulletin. (3-533)

Plastic Laminate. Continental Can Co. (3-475)

Non-Metallic Materials. Continental-Diamond Fibre Co. (3-516)

Pyrex Piping. Corning Glass Works. (3-463)

Plastic Tubing. Dow Chemical Co., Plastics Div. (3-365)

Plastics in Product Design. Durez Plastics & Chemicals, Inc. (3-93)

Plastic Data Book. Formica Insulation Co. (3-210)

Vibration Mounts. Hamilton Kent Manufacturing Co. (3-521)

Plastic Custom Molding. Imperial Molded Products Corp. (3-389)

Plastics. Monsanto Chemical Co., Plastics Div. (3-348)

Molded Plastic Products. Plastic Manufacturers, Inc. (3-430)

Plastics. Richardson Co. (3-403)

Corrosion Resistant Products. U. S. Stoneware Co. (3-176)

Ceramic Plastics. Westinghouse Electric & Mfg. Co. (3-236)

POWDER METALLURGY

(See also Sec. 2—Special Metals; Sec. 3—Metal Parts; and Sec. 8—Metal Powder Processing)

Powder Metal Bearings and Parts. Chrysler Corp., Amplex Div. (3-473)

Powder Metallurgy Parts. Moraine Products Div., General Motors Corp. (3-139)

Powder Metallurgy Products. Powder Metallurgy Corp., Div. Gen. Bronze Co. (3-89)

TUBING

Plywood Tubing. Plymold Corp. Plytube, a laminated tubing fabricated from thin veneers and a water-proof plastic resin, is discussed in a 6-page, illustrated folder. (3-524)

Composite Tubing. Summerill Tubing Co. Bi-metal composite tubing in countless combinations and thicknesses of brass, aluminum, nickel, silver, copper and steel is described in a one-page, illustrated reprint. (3-522)

Fabricated Tube Parts. Wolverine Tube Div., Calumet & Hecla Consolidated Copper Co. This attractive, 32-page bulletin describes and illustrates the fabricating of tubular parts of seamless copper, brass and aluminum. Numerous charts and tables are included. (3-531)

Piping. Flori Pipe Co. (3-345)

Steel Analysis Chart. Globe Steel Tubes Co. (3-485)

Brass Fittings and Tubing. Imperial Brass Mfg. Co. (3-149)

Aluminum Tubing. Reynolds Metals Co. (3-462)

History of Piping. Tube Turns, Inc. (3-303)

OTHER METAL FORMS

Sheet, Wire, Tubing, Etc. D. E. Makepeace Co. This attractive, 4-page bulletin profusely illustrates and describes sheet, wire, tubing and assemblies of laminated or solid precious metals, for use in radio and Radar parts, collector rings, and other specialized fabrication. (3-529)

Zinc-Plated Steel. American Nickeloid Co. (3-330)

Weldments. Graver Tank & Mfg. Co., Inc. (3-425)

Nails, Rivets, Etc. John Hassall, Inc. (3-418)

Metal Spinnings. Milwaukee Metal Spinning Co. (3-397)

Springs and Wire Forms. Wickwire Spencer Steel Co. (3-517)

In this Manufacturers' Literature INDEX, new bulletins are given complete reviews, and previously described older bulletins are merely listed in their proper places.

4. Melting • Refining • Casting

ALLOYING AGENTS

Recuperators for the Steel Industry. Fitch Recuperator Co. (4-121)

Titanium Alloys. Titanium Alloy Mfg. Co. (4-128)

AUXILIARIES

Blow-Off Valves. Wm. M. Bailey Co. Both hand- and motor-operated blow-off valves for blast furnace stoves are described and illustrated in a 2-page bulletin. Specifications are included. (4-227)

Mold and Core Hardness Testers. Harry W. Dietert Co. This single page describes and illustrates both a mold hardness tester for measuring surface hardness of green sand molds, and a core hardness tester for measuring surface hardness of baked cores and dry sand molds. (4-226)

Plaster Molds. Castings Patent Corp. (4-218)

Crucible Furnaces. Crucible Manufacturers' Assn. (4-213)

Metal Reclamation. Hardinge Co. (4-163)

Core Oil. Smith Oil & Refining Co., Industrial Oils Div. (4-181)

Mechanical Charging for Cupolas. Whiting Corp. (4-136)

REFINING AGENTS

Calcium. Electro Metallurgical Co. (4-87)

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MELTING FURNACES, MACHINES AND PARTS

Open-Hearth Furnace. Day & Zimmermann, Inc. An interesting article on a cross-fired open-hearth furnace, which uses nine small burners in staggered positions in front and back walls rather than one large burner in the ends, is presented in a 16-page bulletin. (4-230)

Centrifugal Casting Machine. Ecco High Frequency Corp. Two types of centrifugal casting machines for producing precision castings of both non-ferrous and ferrous metals are described in a 2-page bulletin. (4-225)

Die Casting Machines. Kux Machine Co. A complete line of convertible die casting machines, hydraulically operated, is presented in a 16-page, illustrated bulletin. Specifications are included. (4-228)

Die Casting Machine. Lester-Phoenix, Inc. Two new high-pressure fast-cycling die casting machines—the HHP-1 for zinc, tin and lead, and the HHP-1CC for aluminum, brass and magnesium—are described and illustrated in a 4-page bulletin. (4-229)

High Frequency Furnaces. Ajax Electrothermic Corp. (4-60)

Laboratory Crucible Furnace. Campbell-Hausfeld Co. (4-105)

Rocking Electric Furnace. Detroit Electric Furnace Div., Kuhlman Electric Co. (4-188)

Melting Furnaces. Fisher Furnace Co. (4-217)

Degassing of Aluminum Alloys. Foundry Services, Inc. (4-211)

Die Casting Machine. H. L. Harvill Mfg. Co. (4-222)

Regenerative Furnace Control. Morgan Construction Co. (4-102)

Electric Melting Furnaces. Pittsburgh Lectromelt Furnace Corp. (4-61)

Electric Melting Furnaces, Top Charging. Swindell-Dressler Corp. (4-71)

RAW MATERIALS

Ingot Metals. Ajax Metal Co. (4-108)

5. Heating • Heat Treatment

ATMOSPHERES AND GENERATORS

Inert Gas. Davison Chemical Corp. Complete data on inert gas for blanketing, purging and process are presented in a 12-page bulletin, No. 301. Numerous diagrams and tables are included. (5-588)

Anhydrous Ammonia. Armour Ammonia Works. (5-435)

Anhydrous Ammonia. Barrett Div., Allied Chemical & Dye Corp. (5-569)

Gas-Cracking Unit. Hevi-Duty Electric Co. (5-344)

Bright Annealing of Metals. Lindberg Steel Treating Co. (5-576)

Drying Air or Gases. Pittsburgh Lectrodryer Corp. (5-500)

AUXILIARIES

Alloy Pots. Sterling Alloys, Inc. Bulletin No. 10, eight pages, is a revised reprint of an article on the design, application, selection and operating care of alloy pots for various heat treating mediums. (5-585)

Specifications and Heat Treating Chart. Chicago Flexible Shaft Co. (5-264)

Pressed Steel Pots. Eclipse Fuel Engineering Co. (5-352)

Infra-Red Processing. Fostoria Pressed Steel Corp. (5-428)

Industrial Sub-Zero Machines. Kold-Hold Manufacturing Co. (5-328)

Industrial Chilling Unit. Motor Products Corp., Deep-Freeze Div. (5-417)

Butterfly Valves. R-S Products Corp. (5-348)

Cooling Coils. Trane Co. (5-323)

BATHS AND COMPOUNDS

Balanced Carburizing Baths. American Cyanamid & Chemical Corp. (5-135)

Quenching Oils. Gulf Oil Corp. (5-455)

Neutral Baths. A. F. Holden Co. (5-498)

Salt Baths. Park Chemical Co. (5-334)

BLOWERS AND COMPRESSORS

Blower Catalog and Data Book. Ilg Electric Ventilating Co. (5-228)

Blowers, Gas Boosters, Etc. Roots-Connersville Blower Corp. (5-192)

BURNERS

Gas Burners and Combustion Equipment. Burdett Manufacturing Co. (5-534)

ELECTRICAL HARDENING AND HEATING

Electric Forging Heaters. American Car & Foundry Co. (5-23)

Electronic Induction Heaters. General Electric Co. (5-464)

High Frequency Generators. Induction Heating Corp. (5-232)

High Frequency Heating. Lepel High Frequency Laboratories, Inc. (5-340)

FURNACES

Gas-Carburizing Furnace. Lithium Co. The Lithcarb gas-carburizing furnace that produces clean, bright carburizing, leaving no scale, soot or tars, is described and illustrated in a 4-page bulletin. (5-586)

Convection-Heated Furnaces. Surface Combustion Div., Gen. Properties Co., Inc. Bulletin No. SC-122, four pages, describes and illustrates a variety of pit-type convection rod annealing furnaces, and includes a table on Rockwell hardness vs. drawing temperature. (5-584)

Electric Furnace. Thermo Electric Mfg. Co. The new Temco Model OFE electric furnace for use in metal working shops and laboratories is described and illustrated in a 2-page bulletin. Specifications are included. (5-590)

Electric Pot Furnaces. American Electric Furnace Co. (5-97)

Continuous Heating Machines. American Gas Furnace Co. (5-462)

Blowerless Furnaces. Baker & Co., Inc. (5-574)

Furnaces. Barkling Fuel Engineering Co. (5-580)

Bright Annealing Furnaces for Stainless Steel. Drever Co. (5-224)

Bright Annealing. Electric Furnace Co. (5-44)

Electric Furnaces. Harper Electric Furnace Corp. (5-549)

Electric Furnaces. C. I. Hayes, Inc. (5-499)

Heat Treating and Laboratory Furnaces. K. H. Huppert. (5-303)

Tempering and Drawing Furnace. Johnson Gas Appliance Co. (5-307)

Heat-Treat Furnaces. Lindberg Engineering Co. (5-414)

Heat-Treat Furnaces. Mahr Manufacturing Co. (5-470)

Pot Furnaces. W. S. Rockwell Co. (5-550)

Heat Treating Furnaces. Salem Engineering Co. (5-341)

Tube Furnaces. Sentry Co. (5-510)

Electric Salt Bath Furnaces. Upton Electric Furnace Div., Commerce Pattern Foundry & Machine Co. (5-217)

Induction Heating Units. Van Norman Co. (5-396)

Heat Treating Furnaces. Vulcan Corp. (5-243)

OVENS

Foundry Ovens. Despatch Oven Co. A combination gas- and oil-fired continuous conveyor foundry oven, horizontal type, is featured in a 4-page, illustrated bulletin, No. 30. (5-587)

Constant Temperature Cabinets. Precision Scientific Co. (5-413)

Heating Equipment. Harold E. Trent Co. (5-578)

PROCESSES

Salt Bath Quenching Processes. Ajax Electric Co., Inc. An interesting article on the development and application of isothermal quenching is presented in a 10-page, illustrated reprint. (5-591)

High-Speed Direct Air-Gas Heat. American Gas Assn. Complete data on the physical and metallurgical effects of high-speed direct air-gas heat on metals are presented in a 32-page, illustrated bulletin, No. 48. (5-589)

Surface Hardening. Chapman Valve Mfg. Co. (5-149)

Sub-Zero Treatment for Tools. Alfred Heller Heat Treating Co. (5-575)

Wear Phenomena. Nitralloy Corp. (5-541)

6. Refractories • Insulation

Insulating Fire Brick. Armstrong Cork Co. Five types of fire brick for temperatures up to 2600 F. are described and data on suspended arches and walls and tailor-made arches and domes presented in an 8-page, illustrated bulletin. (6-179)

Refractories. Illinois Clay Products Co. A complete line of fire clay products and Thermo-O-Flake high-temperature insulating products is described in a 2-page bulletin. (6-178)

Cupola Blocks. Ironton Fire Brick Co. Complete data on "Ironton" cupola blocks, highly refractory and resistant to abrasion, slag action and mechanical shock, are presented in a 4-page, illustrated folder. Specifications are included. (6-176)

Bonding Mortar. M. W. Kellogg Co. This 2-page, illustrated bulletin describes Dry Ignisite, an air-setting, high-temperature bonding mortar that is ready for use, when mixed with water, in annealing and heating furnaces, boilers, coke ovens, etc. (6-177)

Heat Transmission. Atlas Lumnite Cement Co. (6-136)

Furnace Repair Refractory. Basic Refractories, Inc. (6-168)

Refractory Coating Material. Brickseal Refractory Co. (6-67)

Refractory Skid Rails. Carborundum Co., Refractory Div. (6-160)

Silicon-Carbide Graphite Crucibles. Electro Refractories & Alloys Corp. (6-165)

Masonry Saw. Clipper Manufacturing Co. (6-82)

Flux Resistant Refractory. Corhart Refractories Co. (6-95)

Ramming Mixtures. Harbison-Walker Refractories Co. (6-130)

Monolithic Linings. Laclede-Christy Clay Products Co. (6-91)

Brick Linings. Plibrico Jointless Firebrick Co. (6-124)

Refractory Products. Charles Taylor Sons Co. (6-77)

Silica Tubing and Rod. Thermal Syndicate, Ltd. (6-103)

Insulating Cement. Universal Zonolite Insulation Co. (6-175)

7. Welding

BRAZING AND SOLDERING

Silver Brazing Alloy. Handy & Harman. Bulletin No. 11-A, four pages, describes and illustrates the brazing of carbide tool tips with Easy-Flo No. 3, a silver brazing alloy with flow point of 1270 F. (7-350)

Silver Solder Flux. Superior Flux Co. Detailed instructions in the use of Superior No. 6, an alkaline, non-corrosive, non-fuming flux for silver soldering, are presented in a 4-page bulletin. (7-352)

Hard Soldering Flux. Special Chemicals Co. Kwikflux, a hard soldering flux with miracle flowing speed and super wetting action, which can be used with all types of brazing, soldering and welding apparatus, is discussed in a 2-page bulletin. (7-351)

Welding, Brazing Aluminum. Aluminum Co. of America. (7-192)

Silver Flux. Scaife Co. (7-224)

Silver Brazing Alloy. Sherman & Co. (7-324)

ELECTRIC ARC WELDING

Arc Welders. K. O. Lee Co. Complete data on a variety of a.c. arc welders, and their accessories, are presented in a 4-page, illustrated bulletin. (7-348)

Joint Assembly of Electrodes. National Carbon Co., Inc. The second in a series of bulletins on electrodes presents instructions for both vertical and horizontal joint assembly of Acheson graphite electrodes and National Carbon electrodes, six pages. Specifications are included. (7-347)

Arc Welding Electrodes. Allis-Chalmers Mfg. Co. (7-312)

Tool Steel Electrodes. Alloy Rods Co. (7-325)

Electrodes. American Agile Corp. (7-233)

Electrode Color Chart. Arcos Corp. (7-78)

Arc Welding Accessories. General Electric Co. (7-188)

Arc Welders, Cranes, Etc. Harnischfeger Corp. (7-333)

Arc Welders. Hobart Brothers Co. (7-242)

Welded Design. Lincoln Electric Co. (7-343)

Arc-Welding Electrodes. McKay Co. (7-164)

Arc Welding Electrodes. Metal & Thermit Corp. (7-47)

Arc Starting Machine. Mid-States Equipment Co. (7-234)

Stud Welder. Nelson Specialty Welding Equipment Corp. (7-331)

Weld Rod Coatings. Philadelphia Quartz Co. (7-248)

Welding Stainless Steel. Republic Steel Corp. (7-143)

Corrosion- and Abrasion-Resistant Alloys. Wall-Colmonoy Corp. (7-123)

Tool Steel Welding Electrodes. Welding Equipment Supply Co. (7-327)

GAS WELDING

Acetylene Generators. Air Reduction Co. Airco acetylene generators, both stationary and portable types, for operating either positive or low pressure welding or cutting torches, are described and illustrated in a 4-page bulletin. Specifications are included. (7-349)

Low-Temperature Welding. Eutectic Welding Alloys, Inc. (7-173)

Welding Torches and Cutting Attachment Parts. Victor Equipment Co. (7-262)

RESISTANCE WELDING

Battery Welding Machines. Progressive Welder Co. Bulletin No. 38, four pages, describes and illustrates two models of battery welding machines for welding both light-duty and heavy-duty work. (7-346)

Welding Electrodes and Alloys. P. R. Mallory & Co., Inc. (7-342)

Current Interrupter. Sciaky Brothers. (7-293)

SUPPLIES

Welding Positioners. Cullen-Friestedt Co. **(7-220)**

Welding Electrodes. Page Steel & Wire Div., Am. Chain & Cable Co. (7-340)

Welding Electrodes. A. O. Smith Corp. (7-261)

Electrode Holders, Etc. Tweco Products Co. (7-336)

Ground Clamp. Will-Weld Mfg. Co., Inc. (7-339)

8. Metal-Working

FORMING

Carbide Mandrels. Carboloy Co., Inc. How to obtain top performance in tube mills, using carbide mandrels, is described and illustrated in a 20-page bulletin. (8-597)

Machine Tool Bases. Central Boiler & Mfg. Co. The advantages of steel plate fabrication when used in the construction of bases, columns or frames of machine tools are discussed in a 4-page, illustrated bulletin. (8-608)

Straightening Presses. Colonial Broach Co. Bulletin No. VL1-44 presents a new line of hydraulic straightening presses, Model VL-1, for handling both finished and rough work, and includes specifications. (8-595)

Hydraulic Presses. Hydraulic Press Mfg. Co. This 4-page bulletin describes and illustrates H-P-M Fastraverse hydraulic presses for deep-drawing both large and small sheet metal parts. (8-591)

Hydraulic Pumps. Lyon-Raymond Corp. Both foot- and hand-operated hydraulic pumps are described and illustrated in a 4-page bulletin, No. 138. Specifications are included. (8-603)

Steel Plate Fabrication. Marine Fabricators Co. The equipment and services available for all types of steel fabrication for various industries are presented in a 4-page, illustrated bulletin. (8-599)

Tangent Bender. Struthers-Wells Corp. Bulletin No. 57-T, four pages, describes and illustrates the new Single Wing tangent bender for smoothly edge-bending sheet metal. Specifications are included. (8-592)

Bushings and Punches. Tool Craft Co. Ready-to-use, press-fit piercing die bushings, piercing die punches and press-fit stripper guide bushings, made of carbon steel in a wide range of sizes, are described and illustrated in a 6-page folder. Specifications are included. (8-607)

Please Use the Coupon on Page 531

100-Ton Molding Press. Watson-Stillman Co. This single sheet describes and illustrates a 100-ton molding press with transfer cylinder, Model No. 9243, and includes specifications. (8-600)

Hydraulic Presses. Anderson Brothers Mfg. Co. (8-279)

Presses. E. W. Bliss Co. (8-228)

Die Matrix Alloys. Cerro de Pasco Copper Corp. (8-106)

Power Presses. Clearing Machine Corp. (8-581)

Hydraulic Presses. A. B. Farquhar Co., Ltd. (8-412)

Hydraulic Presses. Charles E. Francis Co. (8-575)

Sheet Metal Facilities. Kirk & Blum Mfg. Co. (8-333)

Hydraulic Presses. Lake Erie Engineering Corp. (8-248)

Automatic Tubing Machine. Leonard Precision Products Co. (8-587)

Metal Duplicating Without Dies. O'Neil-Irwin Mfg. Co. (8-561)

Tube Benders. Pines Engineering Co., Inc. (8-201)

Cable Swagers. Standard Machinery Co. (8-566)

Laminated Lignin Plastic. Wales-Strippit Corp. (8-515)

FORGING

Forging Furnaces. George J. Hagen Co. (8-230)

MACHINING

Automatic Control. Bullard Co. A new system of control, called Man-Au-Trol, which, when applied to machines, results in increased production, machining accuracy, etc., is discussed in an 8-page bulletin. (8-605)

Precision Tools. Electrix Corp. A complete listing of precision gages, jigs and fixtures, form tools, lamination dies, etc. is presented in a 24-page, illustrated bulletin. (8-601)

Screw Thread Fits. Greenfield Tap & Die Corp. A useful guide to screw thread fits, listing all essential data for each size screw on a single page, is presented in a 40-page manual. (8-606)

Gear Finishers. Michigan Tool Co. A complete line of Model 860-B spur and helical gear finishers, which operate on the crossed-axis gear shaving principle, are described and illustrated in bulletin No. 860-B-44. Specifications are included. (8-596)

Grinder Belt. Minnesota Mining & Mfg. Co. The 3-M abrasive swing grinder belt and segment face contact wheel for high-speed grinding and finishing of flat or curved surfaces are described and illustrated in a 12-page, pocket-size booklet. (8-589)

Manufacturing Service. Oiljak Mfg. Co., Inc. The facilities and services of this company for both ordinary and unusual machining, stamping, welding assembly and finishing projects are offered in a 12-page, illustrated bulletin. (8-604)

Electric Hand Tool. Precise Products Co. This 4-page bulletin describes and illustrates a high-speed electric hand tool, Precise 35, which is cased in plastic and operates at 35,000 r.p.m. (8-602)

Twist Drills. Republic Drill & Tool Co. Complete data on a variety of shankless and all-flute high-speed roll-forged drills and

drill drivers are presented in an attractive, indexed, 150-page catalog, No. 3-D. Specifications, prices and numerous illustrations are included. (8-590)

Ground Thread Taps. Sossner Tap & Tool Corp. A complete line of ground thread taps, and their specifications, is attractively presented in a 76-page, indexed catalog. (8-594)

Clamps and Cylinders. Airop, Inc. (8-584)

Tool Shanks and Cutter Bodies. American Brake Shoe Co., Brake Shoe & Castings Div. (8-361)

Milling Machines. B. C. Ames Co. (8-416)

Special Steel Drills. Black Drill Co. (8-582)

Oil Filters. Briggs Clarifier Co. (8-538)

Surface Grinder. Builders Iron Foundry. (8-576)

Sawing Machine. Continental Machines, Inc. (8-499)

Metal Disintegrator. Drafto Corp. (8-568)

Coolant Cutting Compound. Finegan-Campbell Co. (8-558)

Cutting Steels. General Aircraft Equipment, Inc., Metoloy Div. (8-244)

Utility Sleeve Tool Driver. J. C. Glenzer Co. (8-577)

Hydraulic Surface Grinders. Hill Acme Co. (8-293)

Diamond Wheels. Industrial Abrasives, Inc. (8-578)

Filters. Johns-Manville Corp. (8-316)

Chip Breaker Charts. Kennametal, Inc. (8-238)

Diamond Tools. Larco Diamond Tool Co. (8-551)

Air-Powered Machines, Etc. Myers Engineering Co. (8-560)

Metal-Cutting Tools. Putnam Tool Co. (8-585)

Metal Cutting Machine. Racine Tool & Machine Co. (8-389)

Torque Tools. Richmont, Inc. (8-579)

Cutting Fluids. D. A. Stuart Oil Co., Ltd. (8-580)

Precision Grinding Wheels. Universal Wheel & Abrasive Corp. (8-377)

Liquid Honing Process. Vapor Blast Mfg. Co. (8-475)

Carbide Tools and Blanks. Vascoloy-Ramet Corp. (8-563)

ROLLING

Solid Steel Shear Knives. Heppenstall Co. (8-224)

METAL POWDER PROCESSING

Cone Blender. Patterson Foundry & Machine Co. (8-493)

Mixers, Agitators, Etc. H. K. Porter Co., Inc. of Pittsburgh, Pa. (8-542)

RIVETING AND FASTENING

Insert Kits. Aircraft Screw Products Co., Inc. Bulletin No. 240, four pages, describes and illustrates "Heli-Coil" insert kits for field servicing, salvage and maintenance of stud and cap screw assemblies. Specifications are included. (8-598)

Lock Nuts. Columbia Nut & Bolt Co., Inc. A one-piece, self-retaining nut that can be used for any purpose without injuring the thread on the bolt is described and illustrated in a single sheet. Specifications are included. (8-593)

Post-War Uses of Explosive Rivets. E. I. duPont de Nemours & Co., Inc. Interesting data on the post-war uses of explosive rivets, as well as their present application in the aviation industry, are presented in a new manual. (8-588)

9. Cleaning • Finishing

CLEANING

De-Burring Process. De Burr Barrel Co., Inc. How both soft metal and hardened steel parts are de-burred with a smooth over-all finish with De Burrettes, made from Neoprene rubber impregnated with an aluminum oxide abrasive, is described in a 2-page, illustrated bulletin. (9-499)

Emulsion-Type Cleaner. Pennsylvania Salt Mfg. Co. Pennsalt Cleaner EC-10, a new emulsion-type cleaner for dip cleaning and spray washing, is described in an illustrated, 6-page, pocket-size folder. (9-492)

Sheet Metal Cleaner. Wolfe-Kote Co. This 2-page bulletin discusses triple-duty Krome-Kote, a liquid sheet metal cleaner as well as sealer against rust reforming for steel, aluminum, terne plate, etc. (9-491)

Industrial Cleaning Machines. Alvey-Ferguson Co. (9-251)

Dust Control. American Air Filter Co., Inc. (9-408)

Metal Washing Machine. American Foundry Equipment Co. (9-396)

Deburring and Finishing Wheels. Carborundum Co., Globar Div. (9-360)

Electro-Cleaning. Macdermid, Inc. (9-293)

Industrial Cleaning. Oakite Products, Inc. (9-267)

Batch Cleaning. Optimus Equipment Co. (9-483)

Surface Peening. W. W. Sly Mfg. Co. (9-422)

Spray Nozzles. Spray Engineering Co. (9-190)

CHEMICAL TREATMENTS

Gas-Fired Hot Dip Tanks. Aeroil Burner Co., Inc. This 16-page, illustrated bulletin describes insulated hot dip tanks that are fueled by city or natural gas for use in metal cleaning, degreasing, rust-proofing, etc. (9-496)

Rust Preventive. American Chemical Paint Co. Peroline No. 3, a chemical containing phosphoric acid and film-forming organic compounds that prevents rust on iron and steel, is discussed in Technical Service Data Sheet No. 11-5-3-2, three pages. (9-502)

Black Oxide Finish for Steel. Heatbath Corp. KwikBlak, a low-temperature black oxide finish for steel that is rust-resistant and durable, is discussed in a 4-page, illustrated bulletin. (9-503)

Blackening Iron and Steel. Alrose Chemical Co. (9-95)

Zinc Finish. Chemical Corp. (9-489)

Blackening Aluminum. Enthone Co. (9-278)

ELECTROPLATING

Metal Fluoborates. General Chemical Co. Technical Service Bulletin No. 1015-A, 16 pages, presents complete data on a variety of metal fluoborates, and includes numerous tables and photo-micrographs. (9-506)

Selenium Rectifiers. Federal Telephone & Radio Corp. (9-442)

Copper Plating. United Chromium, Inc. (9-413)

METALLIC COATINGS (NON-ELECTROLYTIC)

Abrasion-Resistant Alloy. Wilcox-Rich Div., Eaton Mfg. Co. Xaloy, a new alloy that has a Brinell hardness of 700 to 750, can be applied to any steel, and is unusually abrasion-resistant, is discussed in a 4-page, illustrated bulletin. (9-498)

NON-METALLIC AND ORGANIC COATINGS

Plastic Coating. American Pipe & Construction Co. The properties, uses and benefits of Amercoat No. 33, a general purpose, cold-applied protective coating, are discussed in a new bulletin. (9-500)

Industrial Finish. Ault & Wiborg Corp. Polymerin-200, an industrial finish that can be sprayed on metal surfaces, resulting in a durable glass-like finish without priming, is discussed in an illustrated, 32-page, pocket-size booklet. (9-505)

Corrosion Preventive Specifications. E. F. Houghton & Co. This 68-page booklet presents a brief description of the principal government corrosion preventive specifications, and the Houghton approved products for each. (9-493)

Protective Coatings. Quigley Co., Inc. Triple-A protective coatings for iron, steel, wood, brick and concrete are numbered and described with a color chart in a 6-page folder. (9-495)

Plastic Coating. Standard Varnish Works. Corex, a thermo-setting plastic that can be brushed, sprayed or dipped, with exceptional corrosion resistant properties, is discussed in a 2-page technical bulletin, No. 2. A table of laboratory tests is included. (9-494)

Pumps for Paints, Sealers, Etc. Stewart-Warner Corp. A variety of Alemite "Versatal" material pumps, air-operated and high-pressured, for paints, sealers and mastics, are described in an 8-page, illustrated bulletin. Specifications are included. (9-497)

Spray Finishing Systems. Binks Manufacturing Co. (9-362)

Rust-Inhibiting Wax Coatings. S. C. Johnson & Son, Inc. (9-234)

Protective Coating. Mitchell-Bradford Chemical Co. (9-450)

Rust Preventive. Nox-Rust Corp. (9-348)

PICKLING

Corrosion Resistant Ceramics. Atlas Mineral Products Co. (9-72)

Ferric Sulphate and Cartridge Cases. Monsanto Chemical Co., Merrimac Div. (9-176)

POLISHING

Buffing Metal Parts. Puritan Mfg. Co. Purico Wonderbar, a presaponified Tripoli composition that removes grease and foreign matter without scrubbing and brushing the metal parts, is discussed in an 8-page, illustrated booklet. (9-504)

Grinding Wheel Selector. Cleveland Quarries Co., Sterling Grinding Wheel Div. (9-358)

Polishing and Buffing. Divine Brothers Co. (9-315)

Rotary Automatics. Hammond Machinery Builders. (9-310)

Deburring and Finishing Metal Parts. Sturgis Products Co. (9-487)

PROTECTIVE PACKING

Plastic Coaters. Youngstown Miller Co. Bulletin No. YM-800, four pages, discusses a variety of YM plastic coaters for melting ethyl cellulose compounds and other plastic coatings used on tools being stored or shipped, as well as low temperature plastics for permanent coatings. Specifications are included. (9-501)

10. Testing • Quality Control

CONTROL INSTRUMENTS

Electric Control. Leeds & Northrup Co. Micromax electric control, duration- adjusting type, for electric furnaces, ovens, baths, etc., is discussed in a 26-page, illustrated catalog, No. N-OOA (2). (10-612)

Thermocouples, Etc. Wheelco Instruments Co. Complete data on the selection of thermocouples, lead wire, protecting tubes, etc., prices and recommendations, are presented in an illustrated, 40-page catalog, No. S2-5. (10-609)

Air Controllers. Bellows Co. (10-602)

Recording, Indicating and Controlling Instruments. Bristol Co. (10-528)

Industrial Control Devices. Brown Instrument Co. (10-254)

Combustion Control. Cities Service Oil Co. (10-518)

Electrical Resistance Recorder. Foxboro Co. (10-600)

Pyrometers. Illinois Testing Laboratories, Inc. (10-483)

Tachometers. Jones Motrola Co. (10-591)

Electric Timers. Paragon Electric Co. (10-605)

Thermocouples, Etc. Revere Co. (10-583)

HARDNESS TESTING

Clamp Screw. Wilson Mechanical Instrument Co., Inc. Bulletin No. G-43, one page, describes and illustrates the "Gripsel" penetrator clamp screw for use on all types and models of the Rockwell hardness tester made since 1930. (10-607)

Hardness Tester for Soft Metals. Barber-Colman Co. (10-218)

Ferrous and Non-Ferrous Hardness Tester. Clark Instrument, Inc. (10-236)

Hardness Testing Equipment. Tinius Olsen Testing Machine Co. (10-542)

INSPECTION DEVICES

Thread Plug Gages. Cadillac Gage Co. Stellite thread plug gages, furnished in all standard sizes from 0.125 to 15 in. in diam., are described and illustrated in a 4-page bulletin. (10-608)

Measuring Surface Roughness. Physicists Research Co. A variety of Profilometers for the measuring of surface roughness are described and illustrated in an 18-page bulletin, No. 108. (10-616)

Testing Methods. Triplett & Barton, Inc. Comprehensive data on the post-war possibilities of prefabrication metallurgical, X-ray and other scientific testing are presented in a profusely illustrated, 20-page bulletin. (10-615)

Vibration Analysis. Westinghouse Electric & Mfg. Co. How to use the Vibrometer for detecting and curing vibration is presented in a 32-page, pocket-size bulletin, No. B-3414. (10-606)

Illuminated Magnifiers. R. P. Cargille. (10-603)

Identification of Steel. Dravo Corp. (10-271)

Magnaflux. Magnaflux Corp. (10-288)

Dynamics Measurement Equipment. Glenn L. Martin Co. (10-601)

Illuminated Magnifiers. E. W. Pike Co. (10-345)

Abrasive Wear Tests. Taber Instrument Co. (10-233)

MECHANICAL TESTING

Mechanical Testing. Riehle Testing Machine Div., Am. Machine & Metals, Inc. (10-455)

Stress-Strain Recording. Baldwin-Southwark Div. (10-318)

METALLOGRAPHIC EQUIPMENT

Metallurgical Testing Apparatus. Buehler, Ltd. (10-80)

RADIOGRAPHY

Inspection Cabinet. Picker X-Ray Corp. This attractive, 16-page bulletin describes and illustrates the Rayproof industrial X-ray inspection cabinet, which offers continuous X-ray examination of parts on a production schedule. (10-614)

Films for Industrial Radiography. Ansco. (10-278)

X-Ray Protection and Light Proofing. Bar-Ray Products. (10-509)

The X-Ray in Industry. General Electric X-Ray Corp. (10-10)

Film Dryer. Pako Corp. (10-588)

SPECTROGRAPHY

Universal Spectrophotometers. Wilkens-Anderson Co. (10-180)

LABORATORY AIDS

X-Ray Spectrometer. North American Philips Co., Inc. The Norelco Geiger-Counter X-ray spectrometer for making quantitative and qualitative analyses of crystalline and certain amorphous substances is described and illustrated in a 2-page bulletin. (10-611)

Magnifier. George Scherr Co., Inc. This 4-page bulletin No. 107, describes and illustrates the Model C Magni-Ray, a magnifier that provides clear, undistorted magnification combined with bright illumination. (10-613)

Laboratory Equipment. Central Scientific Co. (10-507)

High-Speed Electrolytic Analysis. E. H. Sargent & Co. (10-219)

11. Equipment and Machinery, General

Dry Chemical Fire Extinguishers. Ansul Chemical Co. This 12-page bulletin describes and illustrates DuGas fire extinguishers, equipped with Plus-Fifty DuGas dry chemical, which are fast-acting and effective against extra-hazardous fires. (11-310)

Acid-Proof Brick Floors. Belden Brick Co. A new, permanent, acid-proof brick floor that will not crease, groove, chip, dust off or require patching is described and illustrated in a 16-page bulletin. (11-314)

Steam-Oil Pressure Ratio Regulator. Bloom Engineering Co. Bulletin No. 2060, two pages, describes and illustrates a steam-oil pressure ratio valve that controls steam pressure in proportion to oil pressure. (11-316)

Pumps and Gages. Distillation Products, Inc. A complete line of high-vacuum equipment, including glass-metal pumps, metal diffusion pumps, vacuum and ionization gages, etc., is presented in a 34-page, illustrated catalog. Specifications and prices are included. (11-309)

Please Use the Coupon on Page 531

Banding and Splicing Method. Punch-Lok Co. The Punch-Lok streamlined method of banding and splicing electrical applications is described in a 6-page, illustrated folder. (11-307)

Electric Arc Etchers. George Gorton Machine Co. Bulletin No. 1635-B, eight pages, describes and illustrates tracer-controlled electric arc etchers, single or multiple head, for light or deep etching all kinds of metal work of practically any size. (11-305)

Leather Belting. Graton & Knight Co. Complete information on the selection and application of leather belting for power transmission is presented in a 56-page, illustrated manual. Specifications are included. (11-308)

Oil Filters. Hilliard Corp. Bulletin No. 104, two pages, describes and illustrates the Hilco Hyflow portable oil filters for machine tool cutting, lubricating and industrial oils. (11-306)

Wire Stripper. Ideal Commutator Dresser Co. A new two-motor, electric "brush type" wire stripper that cleans coated, glass-covered and cotton-covered wire is described and illustrated in a single sheet. (11-313)

Compressors and Blowers. Ingersoll-Rand Co. A complete line of air-cooled compressors and blowers is profusely illustrated and described in bulletin No. 1011, 22 pages. (11-315)

Trucks, Cranes, Etc. Lewis-Shepard Co. A complete line of materials handling equipment, including lift trucks, cranes, storage racks, stackers, etc., is presented in a 76-page, illustrated catalog, No. 22. (11-312)

Oil Burners. Peabody Engineering Corp. Type M oil burners for use with mechanical, wide range mechanical or steam atomizers are described and illustrated in a 4-page bulletin, No. 802. (11-311)

Colloidal Graphite. Acheson Colloids Corp. (11-114)

Pulverized Coal. Amsler-Morton Co., Inc. (11-162)

Production Research. Battelle Memorial Institute. (11-296)

Centrifugal Pumps. Bell & Gossett Co. (11-304)

Fans and Air Conditioning Equipment. Chelsea Fan & Blower Co., Inc. (11-295)

Mounted Wheels for Portable Tools. Chicago Wheel & Mfg. Co. (11-70)

Filters. Cuno Engineering Corp. (11-121)

Magnetic Separators. Dings Magnetic Separator Co. (11-232)

Linograph Transfer Paper. Eastman Kodak Co. (11-293)

Induction Generators. Electric Indicator Co. (11-301)

Refrigeration and Air Conditioning Equipment. General Electric Co. (11-243)

Fluid Cooler. Gray-Mills Co. (11-211)

Hydraulic Equipment. Hydraulic Machinery, Inc. (11-201)

Impregnating Castings. Jackson & Church Co. (11-222)

After-Cooler. Niagara Blower Co. (11-287)

Dust Preventives. Parsons Engineering Corp. (11-233)

Water Softeners. Permutit Co. (11-75)

Air Processing Equipment. Peters-Dalton, Inc. (11-218)

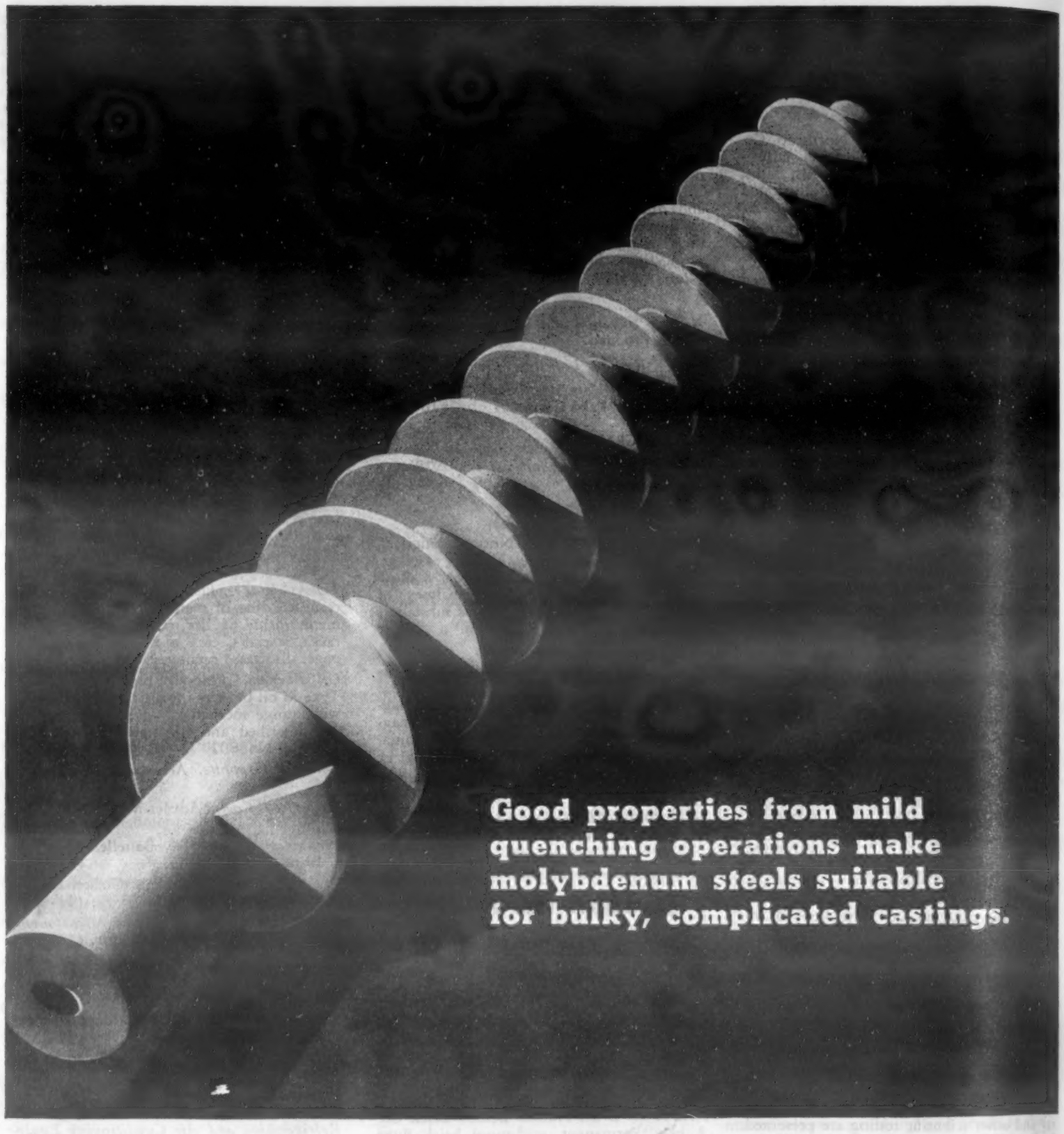
Technical Books. Reinhold Publishing Corp. (11-273)

Lubrication for Steam Turbines. Sinclair Refining Co., Inc. (11-197)

Vacuum Cleaners. Spencer Turbine Co. (11-98)

High Vacuum Pumps. F. J. Stokes Machine Co. (11-152)

Cooling and Conditioning Equipment. Westinghouse Electric Elevator Co., Air Conditioning Div. (11-213)



Good properties from mild quenching operations make molybdenum steels suitable for bulky, complicated castings.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

ARMY E NAVY

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Molybdenum Company

500 Fifth Avenue • New York City

MOLY

engineering NEWS

of the metal-working industries

These rather surprising developments are highly interesting as showing the broad extent to which these materials are being used in the war effort. It would be a satisfaction to know in just what applications the various types are used but some of this is probably a military secret. It would be surprising if the data on these

Demagnetizers

A new line of demagnetizers for completely demagnetizing magnetically soft materials, such as common irons and steels, and partly demagnetizing permanent magnets such as "Alnico," is announced by the *Special Products Div., General Electric Co.* They are designed to demagnetize tools, drills and punches to prevent excessive heat

and wear caused by the adherence of magnetic chips.

They will demagnetize various machined parts, thus releasing fine adhering particles, which often cause severe wear and impair accuracy and appearance. They will also stabilize the magnetic flux in permanent-flux assemblies for such applications as electric instruments and control devices.

Consisting of a cylindrical air-core coil, mounted in a sturdy stand at a convenient 45 deg. angle, these demagnetizers are available in a 4-in. size, rated 115 volts, 60 cycles, a.c. and in 8- and 12-in. sizes, rated 220/440 volts. Long flexible leads, for connection to the power line, are furnished with the 4-in. size, while a small connection box behind the coil of the larger sizes accommodates standard electric conduit.

In operation, rated voltage is applied and the material to be demagnetized is either passed directly through the coil or placed in its center and slowly withdrawn about two feet along its axis. At that point the magnetic field is negligible, and the material is then demagnetized.

For continuous operation, non-metallic conveyor belts can be run through the coil, provided the parts being demagnetized are neither in metal containers nor in contact with each other, so as to cause shielding.

New Industrial Timer

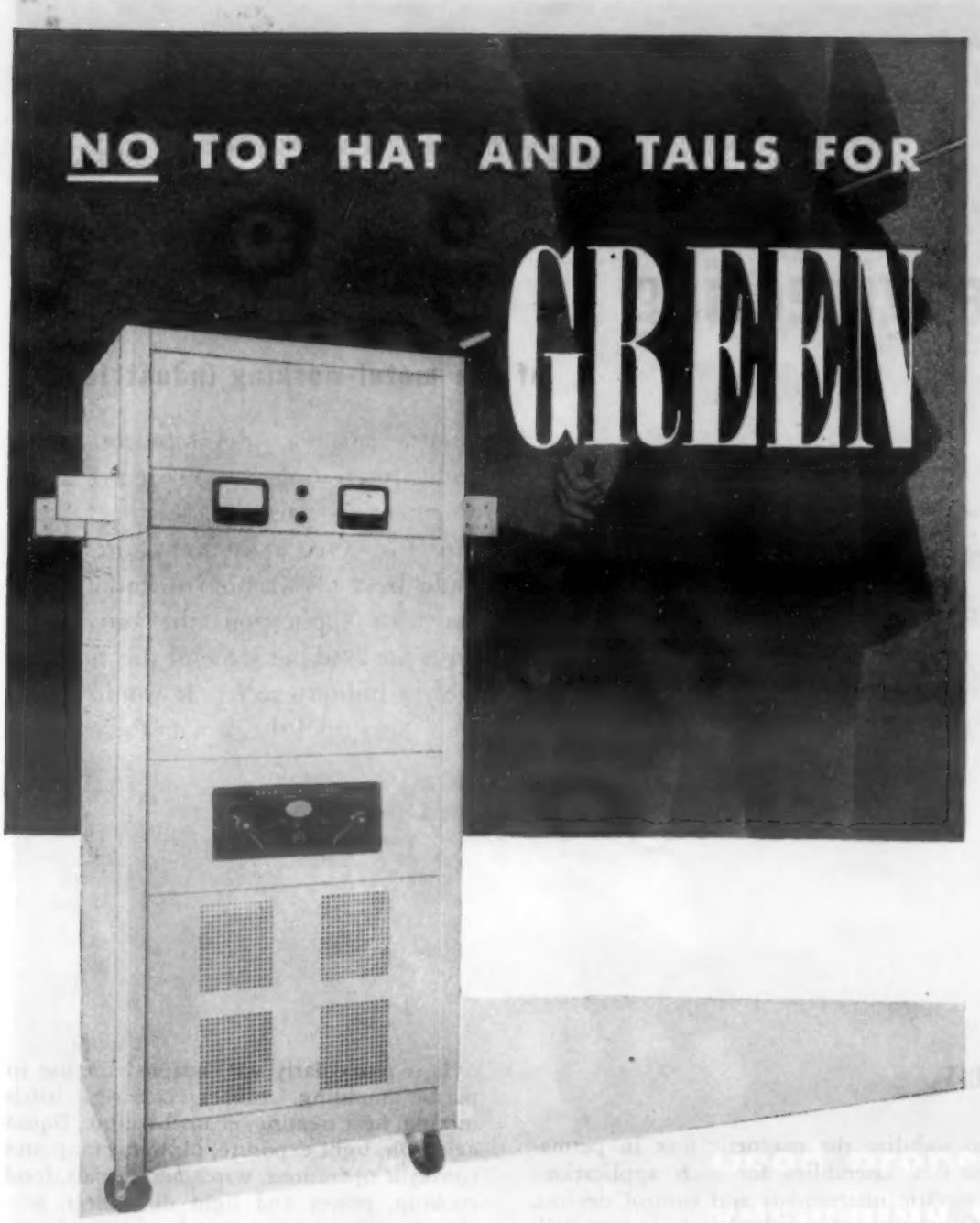
A new manually preset interval timer, having exceptionally wide application, has been announced by the *Paragon Electric Co.*, Chicago. The new model No. 2500 can be preset to allow a given operation to continue for almost any pre-determined time limit; and to close or open a circuit at the end of the preset time.

It is particularly well adapted for use in plastic molding, rubber curving, batch mixing, heat treating, enamel baking, liquid agitation, light exposure, blower, pump and conveyor operations, watchman signals, food cooking, power and light disconnect, machinery operation, control of ventilating fans on a preset schedule, and night heating shut down.

Engineered features are: (1) Switch—single pole, double throw 1,000-Watt capacity, fully enclosed, underwriters having approved; (2) only two exposed gears—motor pinion and wheel, precision hobbed; (3) motor—self-starting, slow speed, industrial-type synchronous, completely sealed; (4) no energy is required of clock motor to trip switch at end of preset time; (5) ten time ranges from 0 to 15 sec. through 0 to 20 hr., available in all types of enclosures; and (6) all parts rust proofed and protected against corrosion.

The 2500 series can be mounted to the surface of any panel or directly to the surface of the equipment the timer is to control. It is also designed to be mounted directly over and to any standard single gang switch box or handy box. It is available for flush mounting or wall mounting with conduit connector. Overall dimensions of the 2500 series are 4⅞ in. high by 3 1/16 in. wide by 2 in. deep.

● Eye glasses, treated with a protective coating to guard against heat breakage and damage from metal spatter, are announced by *Industrial Products Co.*, 2820 N. Fourth St., Philadelphia. Called "Ipco processed cover glasses," they are completely covered on both sides with this tough, baked-on coating that will not pit, peel or rub off.



Though many of our jobs are "exclusive," Green engineers are easy to talk to, and even easier to work with. Because rectifier engineering is our business, we can tackle any assignment —even the so-called insurmountable ones—requiring DC power, and come up with the solution. We have no production line as such . . . each customer's needs are individually thought out, designed and built.

Whatever the voltage and current required, one of our widely used Green Rectifiers can be easily adjusted to your industrial or laboratory applications. Each Green Rectifier is a complete unit in itself, including all control and supervisory equipment. Each is mobile, compact and efficient. Write for our descriptive booklet.

"Rectifier Engineering is our Business"

If you're knitting your brow about DC power, present or post-war, put your problem in the lap of a friendly Green engineer.

SHARE YOUR BLOOD WITH A WOUNDED SOLDIER—THE NEED IS URGENT

W. GREEN ELECTRIC COMPANY, INC.

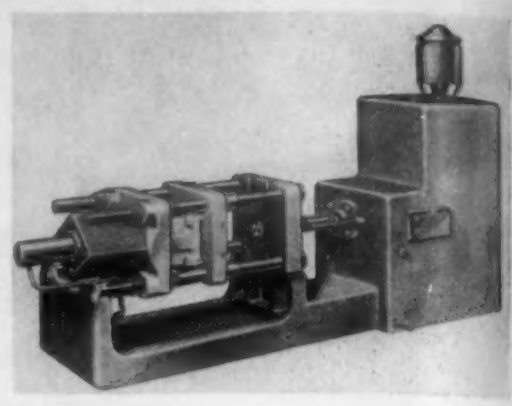
SELECTRO PLATERS AND ALL TYPES OF RECTIFIER EQUIPMENT

GREEN EXCHANGE BUILDING 130 CEDAR STREET NEW YORK 6, N. Y.

RECTIFIER G ENGINEERS

Production Line Die Casting Machine

What is called an "entirely new approach to die casting," or the "complete die casting package," is announced by *H. L. Harvill Mfg. Co.*, Box 335 P, Vernon, Los Angeles. It is a high production cold chamber die casting machine intended for use primarily as a machine tool. It is designed to fit into



metal-working production lines, and is for the use of durable goods manufacturers on a high production basis.

This high pressure cold chamber machine has a patented die locking toggle arrangement that insures positive die closing, completely eliminating, or substantially reducing, the amount of metal flash at the parting line of the dies. An integral two-stage hydraulic system delivers an emulsified water hydraulic fluid at low pressure to operate components of the machine and deliver high pressure fluid for the injection of aluminum-, magnesium- and copper-base alloys.

Pressure of the piston on the metal may be 88,000 p.s.i., with normal pressure of 35,000 p.s.i. With multiple installations, the individual unit system may be replaced by a central source of hydraulic power. The standard machine operates at 400 cycles per hr. The machine can pull cores of a die in four directions. The injection cylinder is at a convenient height and location. It is an all-purpose die casting machine.

Heavy tie bars and oversize platen bearings assure accurate die positioning. For fast die mounting and change, tee slots are provided in the platen. The movement of the platens allows for extremely wide die opening to facilitate casting removal and die mounting. Automatic timing controls regulate all operations except ladling of metal.

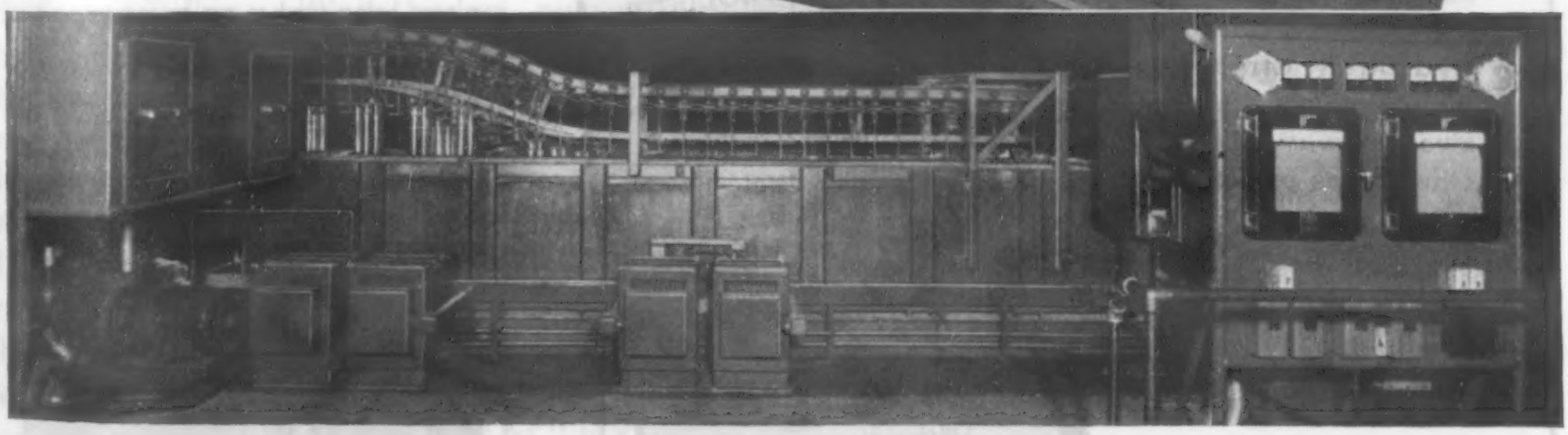
The complete "package" includes standard machine and all necessary accessory equipment for diversified production or the design, construction and installation of fully automatic cold chamber high pressure equipment designed to fit a metal working assembly line. This latter service is an entirely new approach, offering potential increases in production and marked decreases in durable metal goods manufacturing costs.

● New temperature ranges have been added to "Tempilstik" and "Tempilag," which indicate temperatures in industry. They are made by *Tempil Corp.*, 132 W. 22nd St., New York 11. "Tempil" and "Tempil Pellets" are other products of the company.

FULL *BRIGHT* ANNEAL of BRASS CARTRIDGE CASES!

Never before has it been possible to "full anneal" brass with such complete lack of oxidation that subsequent pickling is not required.

The Detroit producer of brass cartridge cases insists that these Upton Salt Bath Furnaces "paid for themselves in the first three weeks of operation."



Ask us for complete information on this or any other difficult heat treating problem.

Upton ELECTRIC FURNACE DIV.

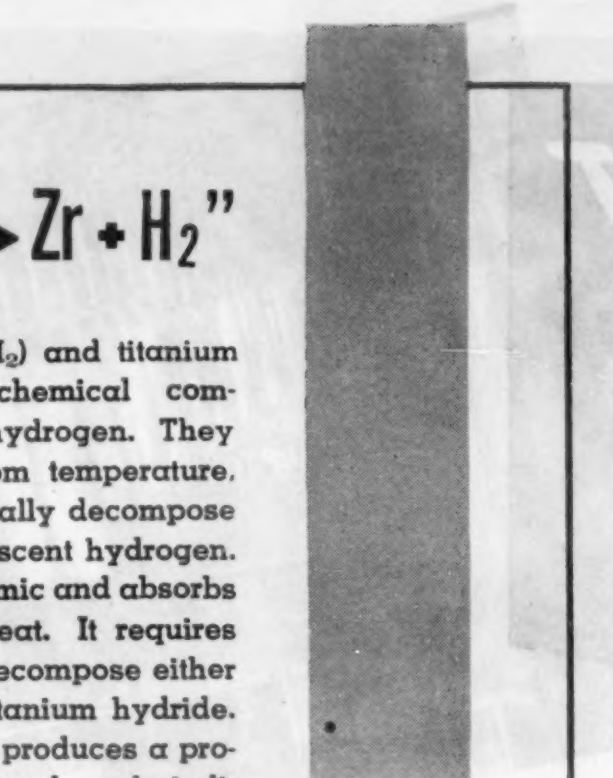
COMMERCE PATTERN FOUNDRY AND MACHINE COMPANY
7425 MELVILLE AT GREEN DETROIT 17, MICHIGAN

"ZrH_2 + heat → Zr + H_2"

Zirconium hydride (ZrH_2) and titanium hydride (TiH_2) are chemical compounds of metal with hydrogen. They are quite stable at room temperature, yet above 300°C gradually decompose into pure metal and nascent hydrogen. The reaction is endothermic and absorbs a certain amount of heat. It requires continuous heating to decompose either zirconium hydride or titanium hydride. The evolving hydrogen produces a protecting atmosphere around each individual particle of the liberated metal.

The above hydrides come in the form of very fine powder of less than 300 mesh. They are not hygroscopic and can be preserved and handled either when perfectly dry or under water. They are not readily attacked by most acids. The most convenient method of storing and handling these powders is in perfectly dry state since then they can be accurately weighed and mixed with other powders, when used in powder metallurgy for the production of sintered alloys. When used in pure state they provide a pure hydrogen atmosphere which protects them and sweeps away all traces of other gases present in the vessel.

These hydrides are metal powders made safe for handling.



METAL HYDRIDES INCORPORATED

Factory Beverly, Massachusetts

Sales Office 17 E. 42nd Street, New York 17, N. Y.

Illuminated Magnifier

An illuminated magnifier, especially designed for detecting cracks, imperfections and blow holes on large castings and called "C Magni-Ray," is announced by *George Scherr Co.*, 200 Lafayette St., New York 12. It can observe a very wide field at one time.

It is encased in an aluminum alloy casting and can be fastened to a machine tool for inspecting turning and grinding operations. The lens is of 5-in. diam. The housing is fastened to a 16-in. upright rod, permitting swiveling up and down and sideways.

Each Model C is equipped with two 4-in. long 25-watt tubular bulbs, especially silvered so that the light is reflected directly upon the work. The base is deep green for eye comfort. It is useful, too, in assembling small and delicate mechanisms and for inspection of ground, polished or lapped surfaces. It is wired for use on a 110-v. current, either a.c. or d.c.

● Marking on X-ray film is easy with the "Handy Floquil Fountain Marker," made by *Floquil Products, Inc.*, 1943 Broadway, N. Y., and used with Floquil marking colors in seven colors. The combination gives clear, clean, waterproof and abrasion proof marking on any surface, wet or dry. The colors dry instantly.

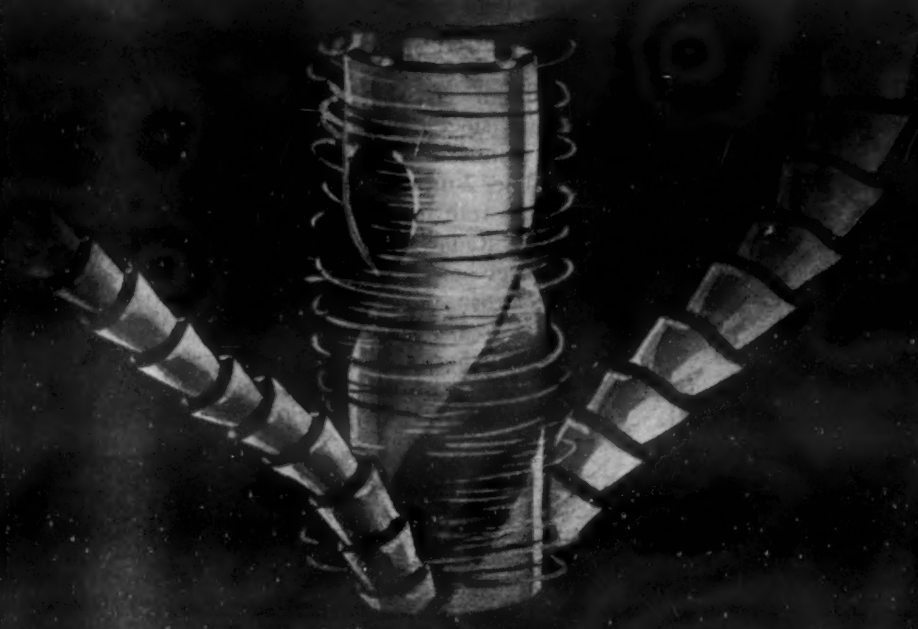
Special Hot Cropper

A special hot cropping machine, using twin water-cooled torches and oxyacetylene, is now being used to cut to measure alloy steel blooms at the plant of *A. M. Byers Co.*, Ambridge, Pa.

Previously, shearing on sizes up to 9 by 9 in. was practicable, but on larger sizes the entire bloom or billet was shipped. This created a special cutting operation at

fabricating plants, as well as a scrap disposal problem there.

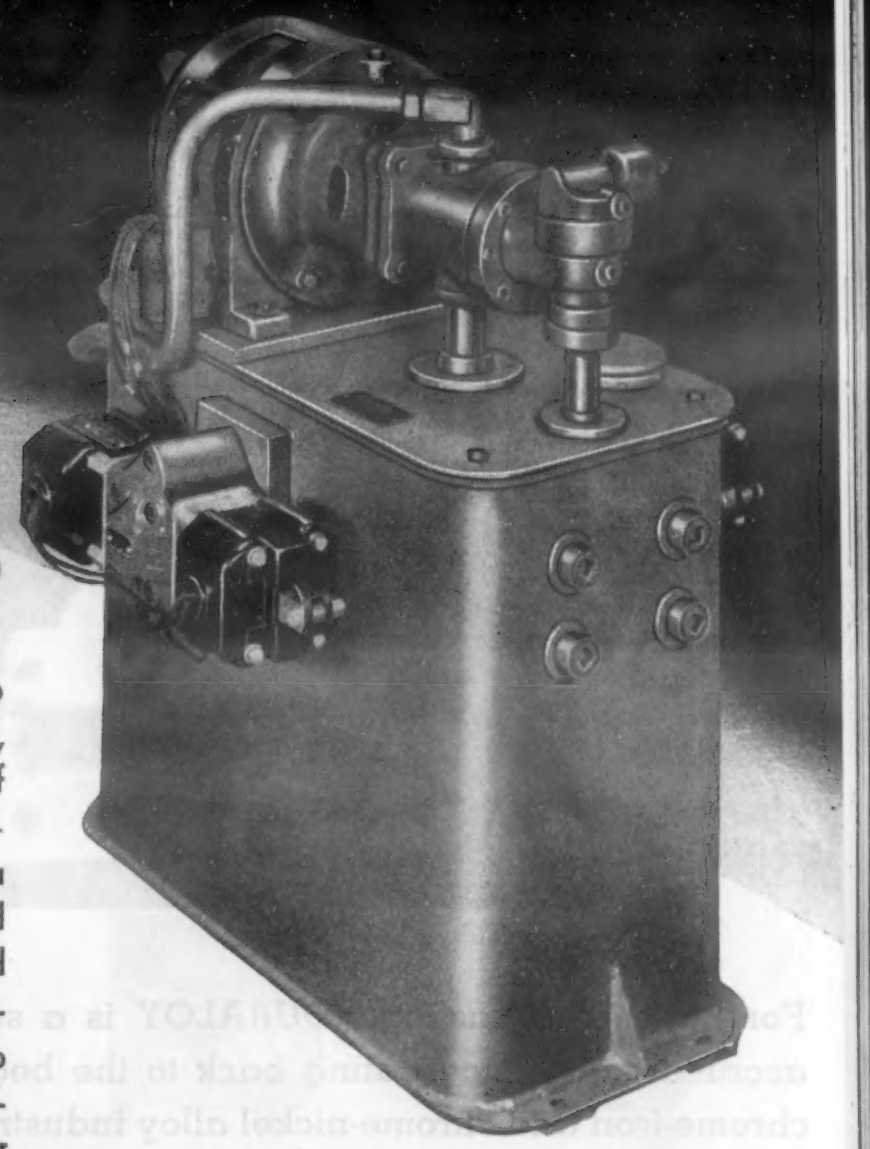
The hot cropper can cut to length all sizes up to 24 by 24 in., achieving economy in shipping and permitting Byers to retain scrap of known analysis at its source and for its own operations. The equipment was designed by Air Reduction Co.



Hydraulics—

COMPLETELY ADAPTABLE TO ANY MOTION DESIRED

"Hy-Mac" Hydraulic Power Units can be applied to drilling, grinding, milling, boring, piercing, riveting, broaching, pressing . . . just determine the functions of the machines that are to be hydraulically operated—and our engineers will recommend a Power Unit and a layout of circuits to best do the job . . . For feed and traverse of multiple or single tools . . . for indexing and locating . . . for clamping, etc., all or any of the movements and in any combination, can be adapted to HYDRAULICS . . . Any designer or builder of machines can accommodate their specific design, either partially or completely to "HY-MAC" HYDRAULICS . . . and our modern plant, together with a comprehensive engineering department is completely competent to handle all of the technical planning, designing, and detailing in connection with building of hydraulic and specific-purpose machinery . . . Our engineers will be glad to make recommendation and preliminary proposal without obligation.



8444-Unit for actuating and controlling a simple feed circuit which incorporates rapid traverse, adjustable feed and rapid return of a single slide —primarily for drill press type of operation but can also be used for the control and actuation of a press or any machine where only one slide is to be controlled.

HYDRAULIC MACHINERY, INC.

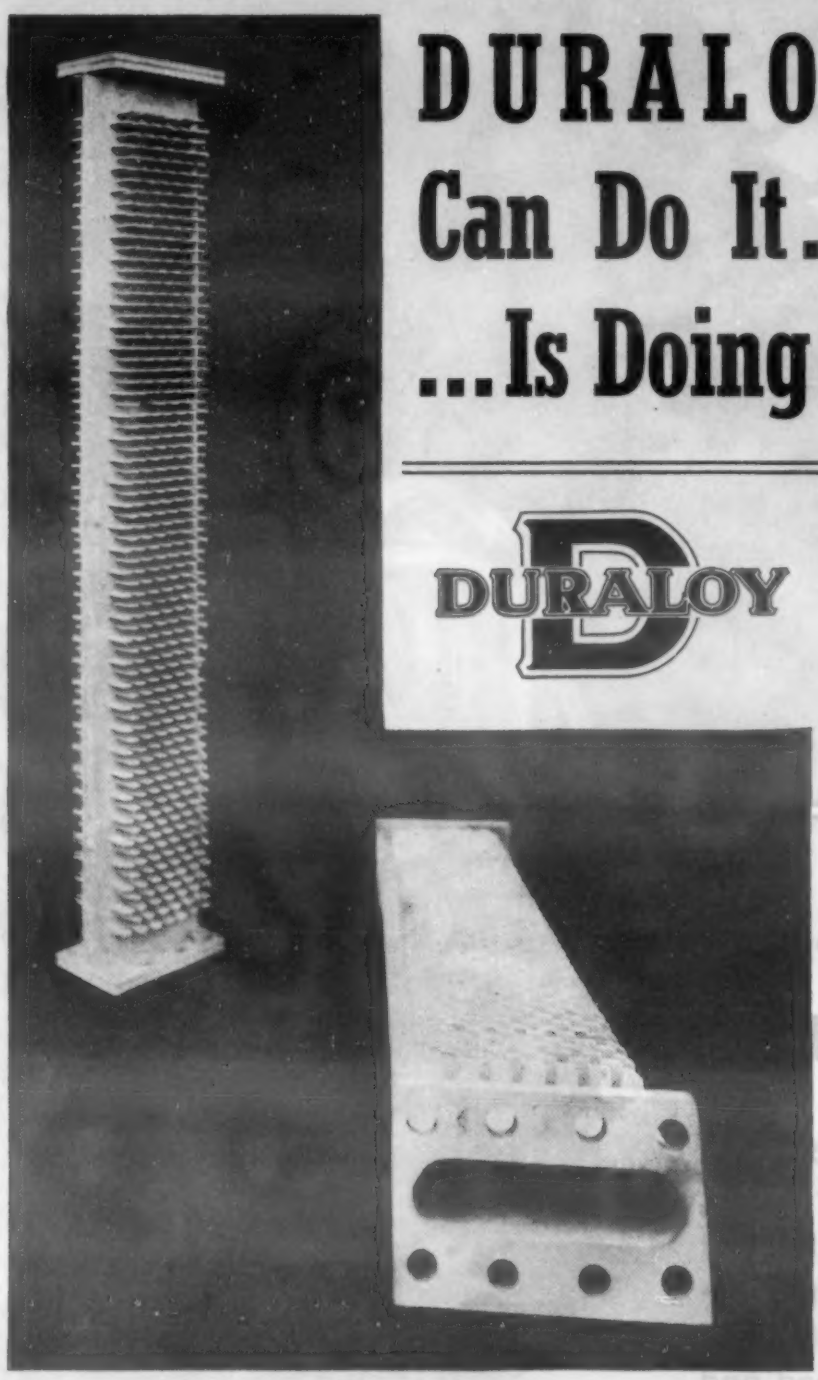
12825 FORD ROAD • DEARBORN, MICHIGAN

HYDRAULIC MACHINERY—Western Division, 1105 N. Pacific Ave., Glendale 2, California

HYDRAULIC MACHINERY

DIFFICULT CASTINGS?

DURALOY Can Do It... ...Is Doing It



DURALOY

For high alloy castings, DURALOY is a sure bet. With accrued experience dating back to the beginning of the chrome-iron and chrome-nickel alloy industry in this country . . . with skilled personnel and superb casting, annealing, machining, and testing facilities, DURALOY stands ready to take care of your high alloy casting problem.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • *Eastern Office:* 12 East 41st Street, New York 17, N. Y.

Los Angeles & San Francisco: KILSBY & GRAHAM

Chicago & Detroit: F. B. CORNELL & ASSOCIATES

METAL GOODS CORP.: St. Louis • Houston • Dallas • Tulsa • New Orleans • Kansas City

2-DU-1

Ultra Thin "Hipersil" for Transformers

To provide an ultra thin alloy steel, "Hipersil," the *American Rolling Mill Co.*, Middletown, Ohio, has developed and built an entirely new type rolling mill. With it, grain-oriented steel, consistent in quality and only 2 mils thick, has been produced, 5-mil steel having been the previous limit of thinness possible.

The 2-mil Hipersil was needed for unusual transformers used in signaling systems, Radar and other very high frequency devices being constructed by Westinghouse. By ordinary standards these transformers are "freaks of the first order." Thus, a transformer no bigger than a fist can deliver 100 kw. (for extremely brief intervals). Another complete transformer weighs ½ oz.

In these transformers, to keep down eddy current losses which at frequencies of several thousand kilocycles tend to eat up appreciable proportions of the meager power available, the core laminations should be very thin—have as much surface as possible. Pre-war standard Hipersil laminations were 14 mils thick; then came 7-mil thickness, used for 400-cycle aircraft transforming equipment, with a 30% saving in total weight; then developed the 5 mil—and now the 2-mil thick steel.

It makes possible transformers in which iron cores have not previously been possible because of the intolerably high core losses. They will be a great boon in television, which requires high peaks of power in pulses lasting but a fraction of a millionth of a second.

Now engineers have produced on an experimental basis a Hipersil steel only half as thick as the 2-mil steel. Four layers of this 1-mil Hipersil would be needed to equal the thickness of typewriter paper. When it can be produced on a commercial basis, it will mean a 20 to 50% further saving in weight and greater powers available for uses of frequencies at the upper end of the frequency spectrum.

Fog-Free Goggles

A new goggle is kept clear of fog, regardless of perspiration by the lung action of the wearer. Normal breathing sweeps a complete change of fresh air in front of the wearer's eyes about once a second, removing moisture before it has a chance to condense as fog on the plastic goggle lens.

A bulbous nosepiece is part of the mechanism which includes flow channels to guide air circulation efficiently and a pump to keep air flowing constantly. Flow channels are in the goggle frame; the pump is the wearer's lungs.

Inhalation draws air through the intake ports, the air sweeping across the inside of the lens, passing through an inlet valve into the nose. Exhalation closes the inlet valve and opens the outlet valve in the base of the protruding nosepiece. Tried out in a machine shop, it reduced eye accidents 50%. It is distributed by the *Welsh Mfg. Co.*, Providence, R. I.

LET US DEMONSTRATE WHAT ELECTRONIC HEATING can do for YOU

PROOF BY TRIAL . . . that's our motto. Before you invest in electronic heating equipment you should be shown how any process requiring heat can be done *better, faster* and *more economically* for you with a Scientific Electric unit.

Our engineers will gladly—*without obligation*—make a study of the heating process under consideration. They will then make recommendations supported by practical demonstrations on the S.E. heater best suited for the job.

This procedure will enable you to figure accurately the economies that will result; also permit you to estimate the time required to pay for the equipment out of resultant savings.

You can submit your heating problems to us with the assurance that absolute secrecy will be observed, if so desired. Investigate the advantages of applying electronic heating in your manufacturing operations NOW. Consult with us at your earliest opportunity.

Write for free copy of
The ABC of Electronic Heating

Manufacturers of
Vacuum Tube and Spark Gap Converters Since 1921

3 KW DIELECTRIC HEATER
Dielectric Heating Units priced from $1500.
(3 KW complete)

5 KW INDUCTION HEATER
Induction Heating Units priced from $1285.
(for 5 KW complete with 1 work coil)

Scientific Electric Electronic Heaters are made in the following range of power;
3—5—7½—8—10—12½—15—18—25—40—60—80—100—250 KW. — and range of frequency up to 300 Megacycles depending on power required.

Scientific Electric

DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. SCIENTIFIC ELECTRIC **GARFIELD, N. J.**

for Alloy Brazing
SCAIFLUX
... it's FAST!
... it's EASY TO USE!
...it's NON-CORROSIVE!
LOW TEMPERATURE BRAZE
FIVE POUNDS
SCAIFLUX
SCAIFE COMPANY OAKMONT PA.
SCAIFE
Scientifically developed by the Scaife Fellowship of Mellon Institute of Industrial Research, thoroughly tested and proved in highly precise war production brazing, SCAIFLUX meets your most exacting requirements. It becomes an adhesive liquid at 160°F. (an important feature), has a wide working range of temperatures, is non-corrosive, water soluble.
Try SCAIFLUX in your production brazing operations for speed, economy and highest quality. Write for complete details today!
SCAIFE COMPANY
(Pittsburgh District)
OAKMONT, PENNA.

New Development in Hot Dope Spraying

"Hot dope" spraying is a new application of an older process to give a protective finish to airplane fabrics on gliders and plywood plane sections on transports and combat planes. For strengthening and stiffening the fabric "dope," it comes close to duplicating the strength of some light metals. The sponsors, *Newell-Emmett Co.*, 30 E.

34th St., New York 16, say that until the development of a "hot dope" spraying system, finishing took 16 laborious operations, many of them manual. By using heat, operations have been reduced to seven and with time cut in half.

The heating converts the "dope" from a molasses-like syrup to a free-flowing consistency for spraying. It was formerly thinned with expensive solvents. The new spraying is called the "Thermotite" system, embracing heating coils, pressure tank, air pump and spray gun. It is used best alongside pre-doped fabrics.

The applicator consists of a standard pressure supply tank; a "Thermotite" unit, consisting of a steam-heated dope reservoir and an air-driven circulating fluid pump to return the dope; dual fluid hose lines, one from the unit to the spray gun, the other from the spray gun through the unit circulating pump, which returns unused dope to the unit heater tank; accessories such as valves, gages, etc.; and a steel cabinet containing the entire assembly.

Power Brushes

A new power brush for removing burrs, preparing metal surfaces and other applications has a cutting rate four times—and a brushing life three times—that of conventional power brushes, states the manufacturer, the *Osborn Mfg. Co.*, 5401 Hamilton Ave., Cleveland.

Called Monitor brush No. 1409-S-22, it is a 12-in. monitor section filled with 0.005-in. power brush wire, with a 1¼-in. arbor hole. It is especially well suited to aluminum, brass and other ductile metals for removing burrs effectively without damaging adjacent surfaces. It is also suitable for hardened and unhardened steel parts. Action is reported smoother than with slower cutting brushes.

PENN SALT Corrosion-Resistant CEMENTS

These times call for *action!* When you build corrosion-resistant equipment, get it into service *fast* with Penchlor* Acid-Proof Cement.

Penchlor Cement is a sodium silicate type cement—quick-setting and self-hardening. No long waits for drying. No acid treatment necessary to harden . . . Penchlor Cement is easy to handle—simplifies construction, speeds repair, saves labor. This cement has *proved* its durability by years of excellent performance in the toughest kind of acid-resistant service.

• Where conditions require a cement of unusual strength and high resistance to abrasion, consider the other Pennsalt Corrosion-Resistant Cements: *Asplit, for conditions always acid . . . *Causplit**, for alternate acid and alkaline conditions. These are easy to handle and will withstand a wide range of corrosive conditions up to 350 degrees F.**

• At your service, without obligation, is the long experience of our engineers in handling acids and alkalis in our own plants. Write fully or if you prefer, use the coupon.

USED BY THESE INDUSTRIES
and many others

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Including galvanizing
MUNITIONS
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PULP AND PAPER
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Also used in the manufacture of:
ALUMINUM • MAGNESIUM • SYNTHETIC RUBBER
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Dept. MA, 1000 Widener Bldg., Philadelphia 7, Pa.

I would like to have a free copy of your booklet No. 6 on Penchlor Acid-Proof Cement.

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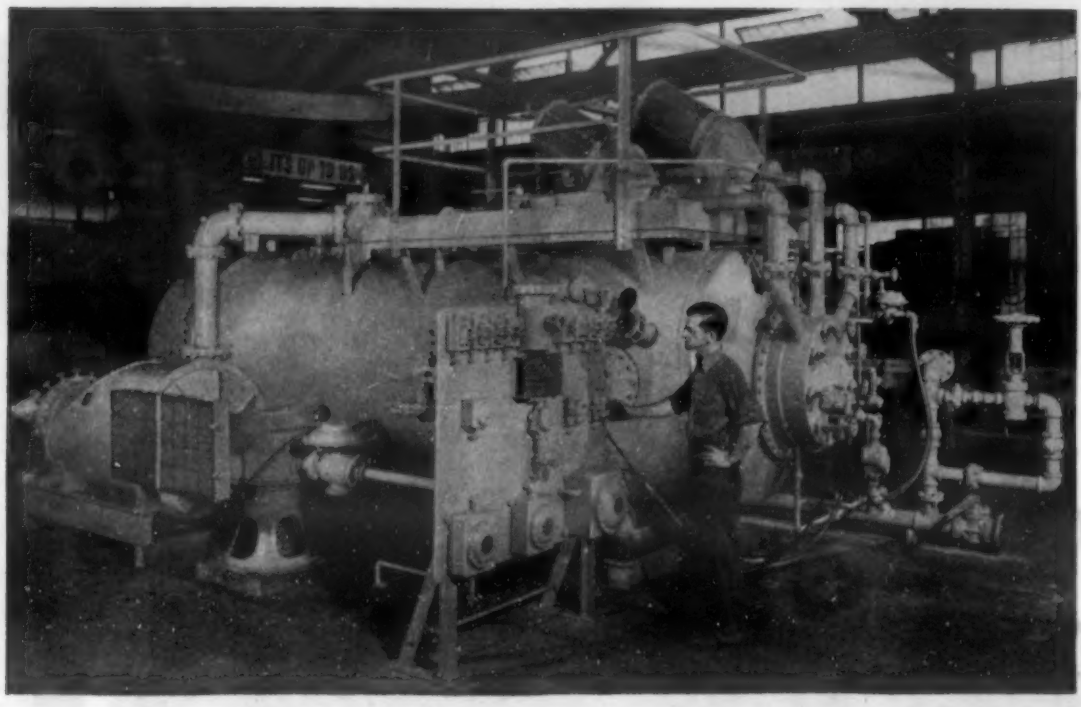
TITLE _____

COMPANY _____

ADDRESS _____



Specify INERTS or NITROGEN by KEMP

FOR PURGING — FOR BLANKETING — FOR PROCESSING

Kemp Inert Gas Producers and Kemp Nitrogen Generators are available in standard models with capacities ranging from 1000 to 100,000 cubic feet per hour—larger sizes and special models built to order.

Features on all models: Flexibility—gas production automatically responds to demand at any rate up to 100% of capacity, thus frequently eliminating need for gas-holders or accumulators to meet peak loads. Safety features include: electric ignition, safety-pilot, soft heads, and automatic shut-down in the event of (a) burner outage, (b) cooling water failure, (c) power failure, (d) fuel gas failure, and safety purging of unit on shut-down or before starting. Units may be furnished for either semi- or fully-automatic operation.

Safeguard against explosion hazards from flammable vapors or explosive dusts with low-cost Inerts or Nitrogen from Kemp Generators. Write for engineering data, recommendations and quotations.

Ask For Bulletin 901.3

OTHER KEMP PRODUCTS

Nitrogen Generators • Inert Gas Producers
Atmos-Gas Producers • Immersion Heaters
Flame Arrestors for vapor lines, flares, etc.
The Industrial Carburetor for premixing gases
Submerged Combustion Burners
A complete line of Industrial Burners, and Fire Checks.

Address The C. M. Kemp Mfg. Co. 405 E. Oliver St., Baltimore-2, Maryland.

KEMP of BALTIMORE

Process for Plating Upon Aluminum

A new simple process for preparing aluminum for electroplating, called "Alumon," is announced by the *Enthone Co.*, 513 Elm St., New Haven, Conn. It handles all types of aluminum, rack and bulk work.

One cleans in the usual manner, then dips in "Alumon," which produces an active alloy base that can be subsequently copper- or silver-plated. After a short copper plate it can be electroplated with nickel, chromium, gold, etc.

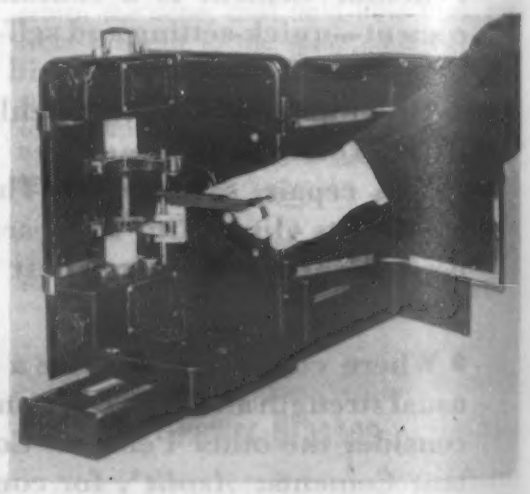
It is now widely used for plating aluminum radar equipment, and can be used in post-war for costume jewelry, amulets, pencil points and household goods.

Work so plated can stand severe distortion without flaking and can be readily soldered. The process is patented, and the user is granted a license with no royalty payments other than the cost of the salts.

Universal Arc Spark Stand

A universal arc-spark stand for spectrography that combines good features of the conventional stand used in general arc work, of the jig-loaded stand for metal rod analysis, and of the Petrey stand for metal plate analysis is announced by *Harry W. Dietert Co.*, 9330 Roselawn Ave., Detroit 4.

Called the "ARL-Dietert" unit, it is completely enclosed, the door being furnished with a safety switch to obviate the hazard of shock, and with a dark red transparent plastic panel that allows good discharge visibility, safe for the eyes. The stand is made of large aluminum castings.



Massive steel electrode holders are water-cooled, while specially insulated tubing on the water system prevents power leakage or breakdown. A unique friction drive positions the electrodes, providing a 1-in. continuous travel on both upper and lower holders, minimum spacing of ⅝ in. between holders and maximum of 2⅝ in. Calibrated stops limit each electrode holder's motion at top and bottom, adjustable to 0.002 in. with a vernier knob.

Used as a jig-loaded stand, holders are locked in place and an accompanying jig

(Continued on page 548)

HERE TODAY— AND HERE TO STAY . . . .

New Standards of Brazing Speed, Quality and Economy set by

SIL-FOS and EASY-FLO

Typical of the wide-scale use of SIL-FOS and EASY-FLO in mass production brazing is this engine-thermo-couple job. With the simple EASY-FLO brazing set-up shown, using foot-controlled carbon electro heating, 180,000 assemblies were completed in fast time. Insulation was undamaged, thanks to EASY-FLO's low flow point.

These two low temperature silver brazing alloys, created by Handy & Harman, have made a record, particularly in war production, that is outstanding.

SIL-FOS and EASY-FLO have made brazing one of the fastest production operations. They have set new standards in the strength and other vital properties of brazed joints. They have created a new conception of brazing reliability and economy. They have made practical the labor-metal-cost-saving brazed construction, now used in fabricating a wide variety of parts formerly cast, forged, machined from the solid, bolted, threaded or riveted.

These accomplishments are the direct results of the combination of low working temperatures, silver content and exceptional fluidity inherent in the SIL-FOS and EASY-FLO compositions, plus fast heating and handling methods.

These new SIL-FOS and EASY-FLO brazing standards of speed, quality and economy are here to stay. They will be just as important in tomorrow's peacetime production as they are today. So, start now to put your brazing operations, old and new, on the fast, profitable SIL-FOS and EASY-FLO basis.

GET FULL DETAILS IN BULLETIN 12-A

Write for your copy today

FOR BEST RESULTS—*USE* HANDY-FLUX

To get full benefit of the low flow points of SIL-FOS (1300°F.) and EASY-FLO (1175°F.) you need a flux that also functions at a low temperature. HANDY FLUX was developed by Handy & Harman to meet this requirement. It starts to fuse and dissolve oxides at 800°F., and at 1100°F., is entirely fluid, and dissolves all refractory oxides rapidly and completely. HANDY FLUX has excellent cleaning properties and washes off readily in hot water after brazing. Comes in convenient paste form.

ARMY E NAVY

HANDY & HARMAN

HANDY & HARMAN FOUNDED 1901 QUALITY SERVICE

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KEY TO A PERFECT FINISH
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GRINDING WHEELS AND MOUNTED WHEELS
CHICAGO GRINDING WHEELS—For the duration, sizes up to 3" in diameter only, in various bonds including FV, the bond with a pedigree.
CHICAGO MOUNTED WHEELS—For internal or external grinding, burring and polishing. Made to fit any tool. Many styles, shapes and shank sizes.

Chicago Wheel takes pride in providing you with exactly the wheel you need, for exactly the job you have, to give you exactly the finish you want!

There's half a century of experience behind this, fifty years of specializing on grinding wheels—grinding wheels with hundreds of varieties in shape, size, abrasive and bond formulas, engineered for the right tool speed and work pressure.

COME TO HEADQUARTERS

Our long experience and testing laboratory are at your service, free for the asking. Tell us about your tough grinding or polishing job. Our abrasive engineers will report promptly, give you their tested solution.

TRY ONE FREE—A Chicago Mounted Wheel or an FV Bond Grinding Wheel sent promptly on request. Tell us size preferred and what you have to grind.

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Interested in
☐ Mounted Wheels
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☐ Send test wheel
Size .....

Name .....
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spaces the sample rods rapidly and accurately. Another jig spaces rod carbon electrodes for arc work. A differential tension between holders allows the upper electrode to be racked against the lower for striking the arc and providing exact spacing.

One uses flat specimens by raising the upper electrode out of the way, or removing, putting into place a rotary table which is pinned for exact positioning and allows sparking at three positions on the sample by moving an external lever. A 3° tilt of the table prevents shadowing of the discharge by the overhang of the sample.

Sample height is maintained equally for all three positions, the table height being adjustable to 0.001 in. with a knob and scale, allowing duplication of electrode positions. A fourth position on the external lever provides a gage over the lower electrode, allowing for spacings of 1, 2 or 3 mm. between the sample plate and counter electrode.

A feature of this stand is a positive sample holder, exerting spring tension against the flat specimen top, insuring perfect electrical contact always.

Research Studies in Steel

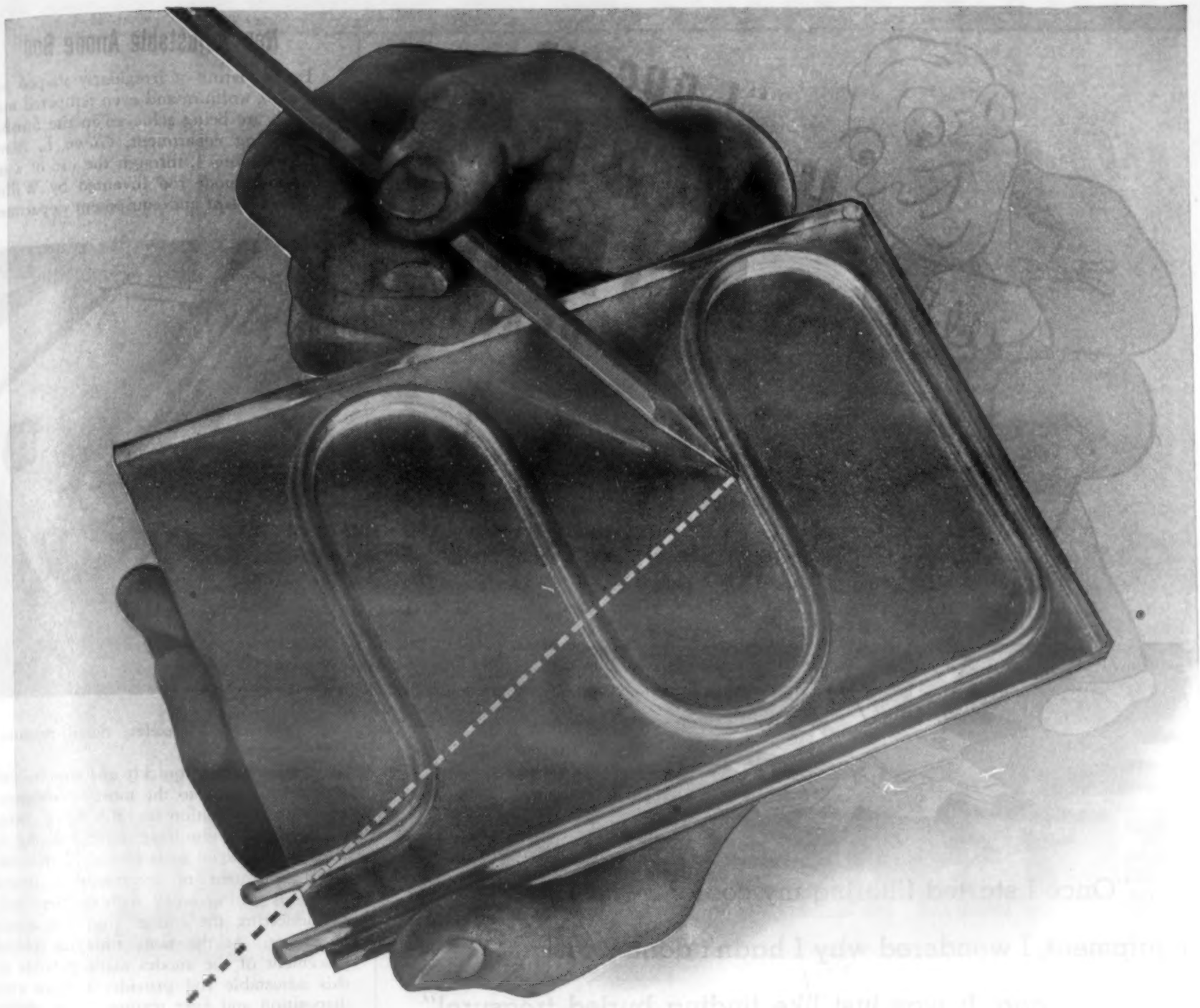
The *American Iron & Steel Institute*, Empire State Bldg., New York, announces several research studies being conducted in the steel industry. A study of the heat treatment and ballistic resistance of steels for light-weight armor plate might appear at first glance to be strictly a war-time project, yet the findings may be valuable in improving steel for coal chutes and other purposes.

Seeking improved steels for guns, several laboratories are cooperating in the study of improved compositions and heat treatments. The results should be applicable to other types of severe service, in post-war automotive engines, for example.

Another study that holds promise of peacetime benefits is devoted to the development of special stainless steel articles, such as springs, where an exceptionally high proportional limit and tensile strength are desired.

A number of research projects are centered upon welding. Fundamental studies on the heat treating characteristics and metallography of boron-treated steels are also being made. A recently developed black oxide coating for stainless steel, which has already been introduced to steel users, is being further pursued from the research standpoint.

Other projects include: Electropolishing processes for stainless steel; the commercial development of stainless steels possessing precipitation hardening properties; the mechanical properties and metallurgical characteristics of low alloy construction steels; research on heat-treated stainless steel for aircraft structural members, research on alloy steel for certain highly stressed aircraft parts, and study of the effects upon steel of extreme cold, such as might be found at high altitudes or in the Arctics.



BRAZING removes an obstacle to rapid heat transfer

Brazing produces excellent joints, speeding up chilling and freezing by making it easy for heat to get out. Use this process in connection with aluminum—a superior heat conductor—and you have the answer to many of your heat transfer problems.

Manufacturers of wartime heat exchangers discovered this early, using furnace-brazed aluminum to obtain highest heat-transfer efficiencies. And they made extremely complicated assemblies which could not have been made by other methods.

Pictured above, you see aluminum tubing furnace-brazed to aluminum sheet, much as you might assemble a refrigerator evaporator, or condenser. Tubing and sheet are bonded into a single, solid unit by an aluminum alloy.

Does this suggest things to you? Alcoa's engineers can help you put your ideas into practice. ALUMINUM COMPANY OF AMERICA. 2162 Gulf Building, Pittsburgh 19, Penna.

ALCOA FIRST IN ALUMINUM

"Once I started filtering my coolant with Hoffman equipment, I wondered why I hadn't done it long ago. It was just like finding buried treasure!"

Hoffman coolant filtration effects large savings in maintenance, in coolant replacement, in longer life for machines, cutting tools and grinding wheels, and in fewer rejects.

ARMY E NAVY

POUGHKEEPSIE PLANT

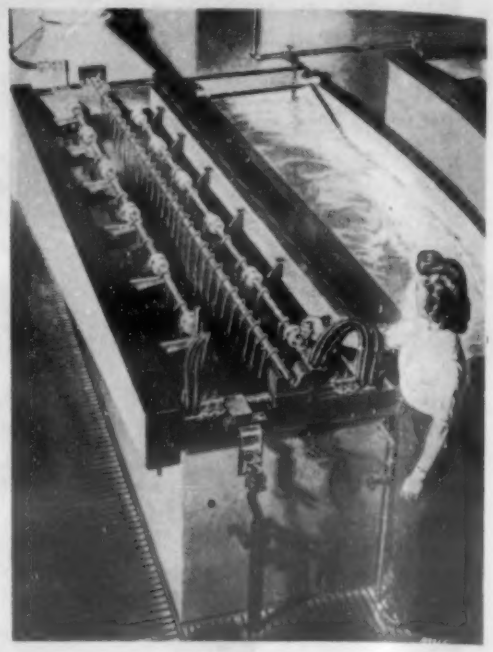
At right: Hoffman Model I-12VC Filter installed on Cincinnati No. 2 Centerless grinder. Other Hoffman models are available for other machines and for installation in large centralized systems.

SEND FOR LITERATURE

U. S. HOFFMAN MACHINERY CORPORATION
223 Lamson St., Syracuse, N. Y.
COOLANT FILTERS · FILTRATION ENGINEERING SERVICE

New Adjustable Anode Rod

Faster plating of irregularly shaped parts and more uniform and even tempered metal deposits are being achieved in the finishing and plating department, *Glenn L. Martin Co.*, Baltimore 3, through the use of a new adjustable anode rod invented by William G. Evans, plant and equipment department,



and William C. Shaefer, detail manufacturing division.

With it one can quickly and conveniently move the anodes to the most advantageous position in relation to the work being plated, thus permitting faster plating of irregularly shaped parts and rapid and positive adjustment to accommodate several types of plating work without electrically disconnecting the anodes from the source of power. At the same time the proper placement of the anodes made possible by this adjustable rod provides a more even disposition and finer texture of the plating material, and reduces the amount of current required.

Designed for use with elongated, mass-production plating tanks, the new installation consists of brackets welded, bolted or riveted to the walls of the tank to which steel plates or arms insulated on either side with phenol fibre are pivotally attached. At the outer end of these plates or arms are swivel fittings on which are mounted annular clamps containing insulators that surround and support the anode rod. The insulators are formed in two halves so that they may be easily installed and clamped in place around the rod. Anode baskets containing chunks or balls of the metal to be deposited are hooked over and supported by the rod.

Current is supplied through a flexible cable attached to one end of the rod, while an insulated handle is provided at the other end to permit the operator to adjust the rod as he sees fit. The rod installation is of sturdy, simple design capable of supporting several hundred pounds of anode material, which can be moved with hardly any effort to any position desired.

In use the operator lowers the work to be plated into the tank, and then by means of the insulated handle, moves the anode rod to place the anodes in the most advantageous

(Continued on page 552)

Do you realize the quenching speed of MAR-TEMP SALT ?

In the interrupted quenching process, speed through the critical zone is important. Mar-Temp Salt, agitated, has a quenching speed equal to that of mildly agitated oil.

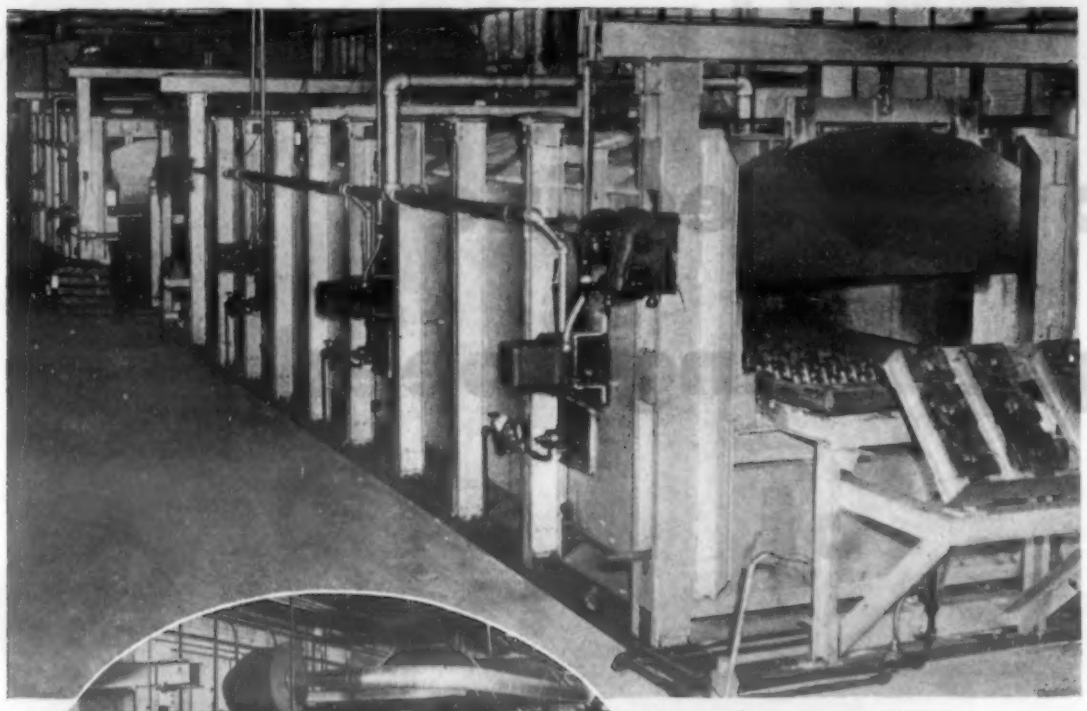
Further, it is stable, fluid, low in melting point, easily removed from the work. For martempering and austempering to combat distortion, cracking or warping, use Mar-Temp.

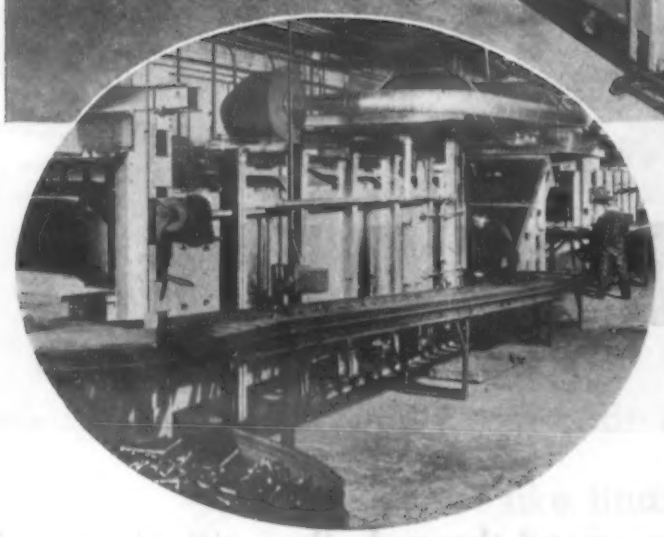
All the way through the heat treat, Houghton salts provide a heating medium unsurpassed for uniform mass-production work. For hardening, carburizing, quenching, annealing, tempering, there is a proven type. And as a plus value, there's the Houghton personalized service, at your command.

E. F. HOUGHTON & CO.
PHILADELPHIA
CHICAGO SAN FRANCISCO DETROIT

HOUGHTON'S *Liquid* SALT BATHS

VULCAN... CONTINUOUS
HARDENING, QUENCHING, DRAWING UNIT





For Treating Miscellaneous Forgings and Castings . . .

PRODUCTION: 1000 lbs. to 1500 lbs. per hour. Engineered by VULCAN to provide fast, efficient operation, with maximum economy. Hardening furnace has roller rail and hydraulic pusher, and operates at temperatures from 1400°F. to 1800°F. It may be oil or gas fired, with two-zone control. Ball-bearing roller conveyor (lower view) returns trays from discharge end to charging end for reloading.

Draw furnace is roller rail, pusher design, with three-zone automatic temperature control, operating at 600°F. to 1400°F. Equipped with same type conveyor as hardening unit, for return of trays.

Although VULCAN Furnaces are engineered to meet specific requirements, they generally cost no more than those of standard design. Consult us regarding your heating and heat treating needs.

VULCAN CORPORATION
1791 CHERRY STREET, PHILADELPHIA, PA.

position for the parts being plated. When the plating is completed, the rods are moved apart, the plated parts removed, new ones placed in the tank and the adjustment process repeated. It makes little difference whether one batch is similar to another, and the whole adjustment process requires only seconds instead of the long periods of time consumed with previous rod mounting methods.

Moreover, at no time during the operation is it necessary to disconnect the rod from the source of power, and the lifting of anode material by the operator is completely eliminated.

In the Glenn L. Martin plating rooms the new rod installations are already credited with saving countless man-hours, and, in addition, have improved the quality of output and cut down on rejections due to coarse textured or uneven coatings. Designs for the adjustable rod will be made available to interested manufacturers of plating equipmen under license.

● *The Corlett-Turner Co.,* 4011 W. Lake St., Chicago 24, announces the "C-T Silent Stock Tubes" for use with automatic screw machines. They are engineered acoustically, so that they eliminate the banging and clattering of bar stock, revolving at high speed in the machine. In closely packed screw machine departments, even when machining hexagonal, square or other "noisy" bars, it is possible to carry on a conversation in a normal voice, where these tubes are used. Such installations have greatly decreased absenteeism of operators, especially among the women, and decreased spoilage, because it permits operators to "listen" to their machines. They can be readily installed on most standard stock stands.

Arc Torch for Electric Welding

A new torch, to be used with electric arc welders, has recently been announced by *Mid-States Equipment Co.,* Chicago manufacturers, and sold under the name "9000 Arc Torch." It provides an electric flame of intense heat, approximately 9000 F., which is a pure heat without oxygen or other gas to contaminate the weld. There is no pressure to force molten metal away or to blow holes in light sections.

The torch can be used with any a.c. or d.c. electric welder for welding aluminum and its alloys, brass, bronze, red brass, phosphorus bronze, silicon bronze, nickel silver, cast iron and other copper and non-ferrous metals and alloys; for brazing steel, cast iron, malleable iron, copper, brass, bronze and other ferrous and non-ferrous metals; for pre-heating all metals prior to welding; for soldering all ferrous and non-ferrous metals; for straightening and bending; and for hard surfacing where wear-resisting metals are used.

It is much more economical to use than gas torches.

UNTREATED ZINC
—No "life" in the finish
—easily tarnished.

CLEAR ANOZINC
— it's got zip — stays clear and bright.

YELLOW ANOZINC
— for applications where a slightly iridescent yellow is desired.

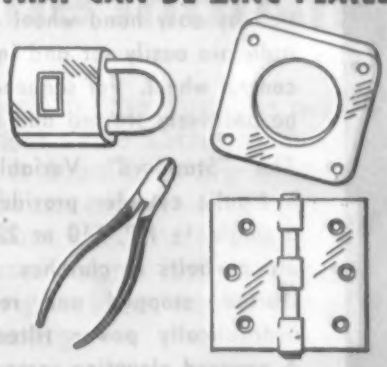
BLACK ANOZINC
—use it where you want a deep, lustrous black.

Unretouched photo shows the slight effect of constant handling over a period of 18 months on pieces treated in the Anozinc bath. Zinc plating identical on all pieces.

When zinc plated parts are finished in a Clear Anozinc bath they keep their sparkle and "zing"—as the photo above shows. It's an inexpensive anodic treatment that retains the appearance of new zinc plating—holds its lustre and attractive appearance—extends its resistance to corrosion and handling—*immeasurably.*

So why use a quickly tarnished finish when this fast, simple procedure will keep your zinc plate dressed up—at low cost? Use the Clear Anozinc bath to produce a finish that's an able pinch-hitter for chromium or cadmium—or wherever better appearance and a more durable zinc surface makes your products more serviceable. Write to the nearest office for further information, giving a brief outline of your application.

CLEAR ANOZINC FOR DIE CAST OR STEEL PARTS THAT CAN BE ZINC PLATED



OTHER U. C. PRODUCTS AND PROCESSES TO SERVE YOU

CHROMIUM PLATING for wear-resisting, oil-retaining and other types of finishes.

☆**UNICHROME ALKALINE COPPER** for smooth, lustrous copper plating in a non-cyanide bath.

☆**UNICHROME STRIP** for speedy removal of copper, chromium, zinc, etc., from steel and cast iron without etching the base.

☆**UNICHROME RACK COATINGS** specially formulated to stand up under the most severe operating cycles.

☆**UNICHROME STOP-OFF LACQUERS AND COMPOUNDS** specially formulated to meet specific plating problems.

☆**UNICHROME CLEAR LACQUERS** specially formulated to meet specific finishing requirements.

☆**UCILON** — a corrosion-resistant coating for protecting surfaces against acids, alkalies, water, gasoline and various corrosive chemicals.

☆Reg. U. S. Pat. Off.

UNITED CHROMIUM
INCORPORATED
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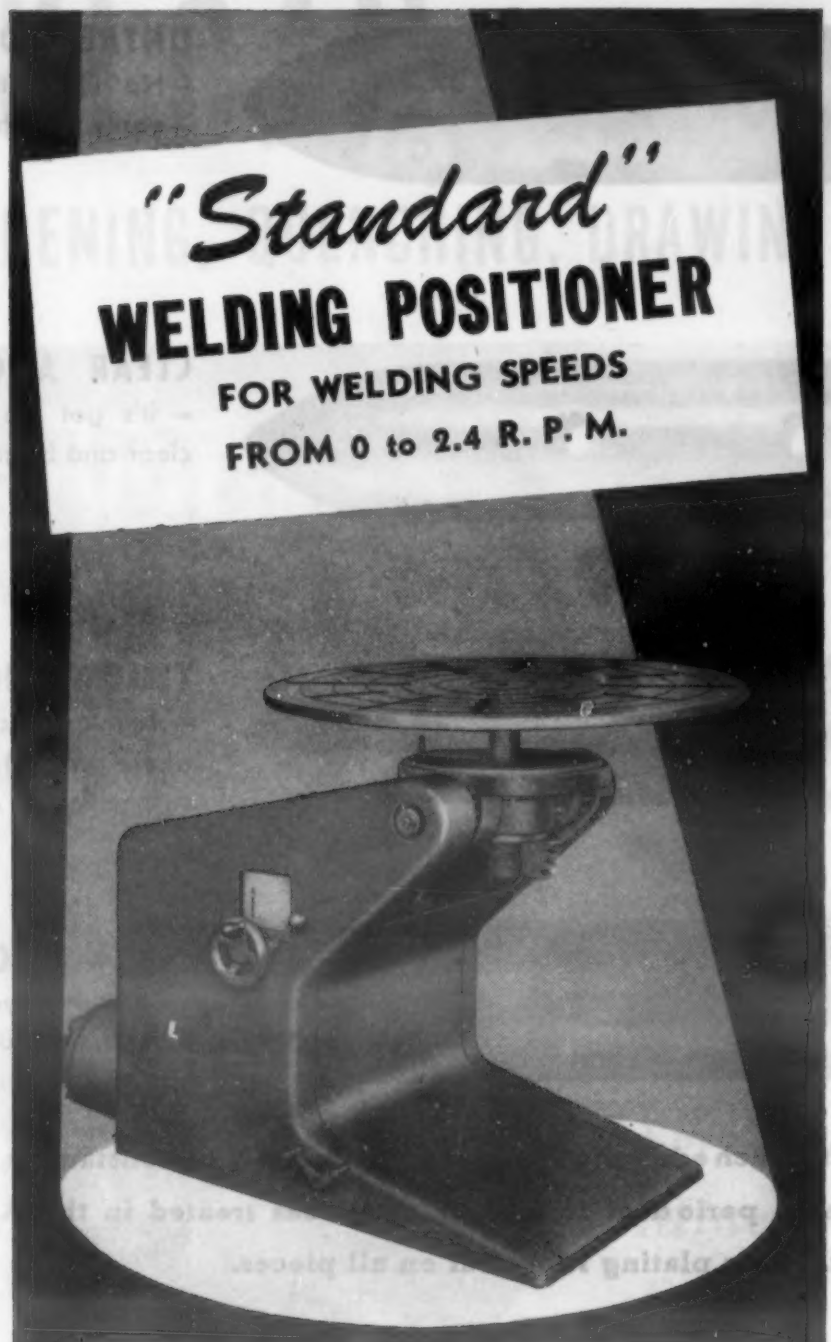


NEW • EFFICIENT • ECONOMICAL

Designed to rotate work up to 700 lbs. in either direction by easy hand wheel control. Linear speeds at all radii are easily set and indicated on chart above hand control wheel. For sequence or step welding, table may be positively started and stopped.

The "Standard" Variable Speed Transmission and hydraulic cylinder provide stepless speed control with a single ½ HP, 110 or 220 volt electric motor. There are no belts or clutches. The rotation of the table is started, stopped and reversed by foot pedal and hydraulicaily power tilted by manual lever control. A powered elevating screw provides adjustment of floor to table height between 30" and 36".

Write for latest information.

Standard
MACHINERY COMPANY
1542 ELMWOOD AVE., PROVIDENCE 7, R. I.

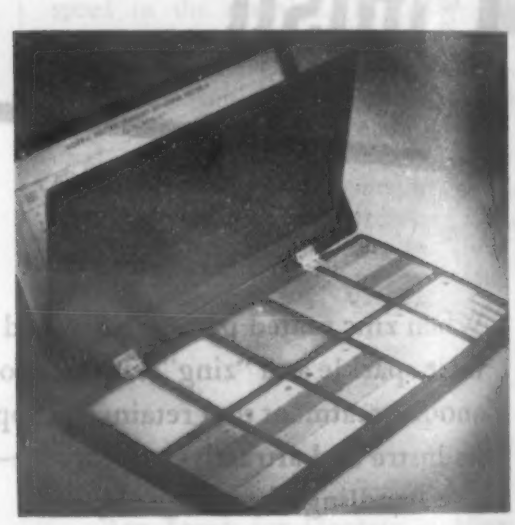
Set of Surface Roughness Specimens

A set of standard surface-roughness specimens, each representing one clearly identified degree of surface roughness ranging from the smoothness of a bearing surface to the roughness of a flame cut, has been announced by the *Special Products Div., General Electric Co.,* Schenectady.

The new specimens are designed to permit the engineer to select and specify by symbol the especial degree of surface roughness allowed for a particular machine part, or for use in the shop to enable the mechanic to determine the exact surface roughness allowed by drawings.

The set consists of ten metal specimens, each approximately 2 by 2½ by ⅛ in. Several are divided into two and in some cases four surfaces, all of which, while equally rough, are produced by different machining methods. In all, the ten specimens simulate 25 surfaces, each surface representing the roughest one acceptable for that particular symbol regardless of the method of producing the finish or the material of which the part under inspection is made.

The specimens are furnished in an attractive 12 by 6 by 1¼ in. cloth-lined wooden case designed both for protection and for convenience in handling. A feature of this case is a separating partition that holds the specimens securely and protects the chart on the inside of the cover, which conveniently lists the symbols of the various specimens for ready reference.



Little experience is required to use the specimens efficiently, since comparison of the surface under inspection with that of the selected specimen is made visually and by the sense of touch.

● Standard cemented carbide tools and blanks are now "packaged for shipment" in quantities up to 100 per carton by *Carboloy Co., Inc.,* Detroit 32. Packages contain quantities, or multiples of quantities of each item most frequently purchased. Thus, turning, facing and boring tools in lots of 12, 6 and 1; blanks for them in 100, 50, 25 or 10. Such packaging results in better protection during shipment and prompter delivery. Cutting tips are dipped in hot plastic, to be peeled off before use.

The Lithium Process Controls at the Work

NEUTRAL HEATING OF ALL STEELS

BRIGHT EUTECTOID CARBURIZING

CARBON RESTORATION

LITHIUM FLUID BRAZING

CLEANING AND DESCALING

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You will find it most interesting as you look ahead and consider the imperative need for higher quality work and lower costs in the coming competitive era.

The Scarlet Flame MEANS LITHIUM

The most talked-of process in the industry

FROM THE START, it seemed obvious to The Lithium Company that the only place to prevent scale and decarburization in the neutral heating of steels is in the heating chamber.

There the metal is heated . . . there it needs protection from the ever-present water vapor, which metallurgists have emphasized for twenty-five years as the active promoter of scale and decarburization. They have repeatedly pointed out that water and oxygen, which combines with hydrogen to form water, seep in and come in on the work. . . that water vapor forms in huge quantities from intergaseous reactions in the heating chamber—that water is always present, even when the atmosphere is pre-dried outside the furnace.

Why not DRY the atmosphere in the heating chamber *at the work?* That is exactly what the Lithium Process does—and does it in a simple way, without scrubbers, refrigerators or other attachments. Lithium metallic vapor is blended in the furnace with a low-cost combustion gas. The Lithium dries up the water by breaking it down into dry hydrogen, forming harmless Lithium oxide—and does this so thoroughly throughout the entire process that the steel comes out unchanged both chemically and physically, so bright that costly cleaning operations are unnecessary.

The same principles apply with equal importance to gas carburizing. Elimination of scale and decarb reactions results in fast, bright carburizing both in and below the eutectoid range.

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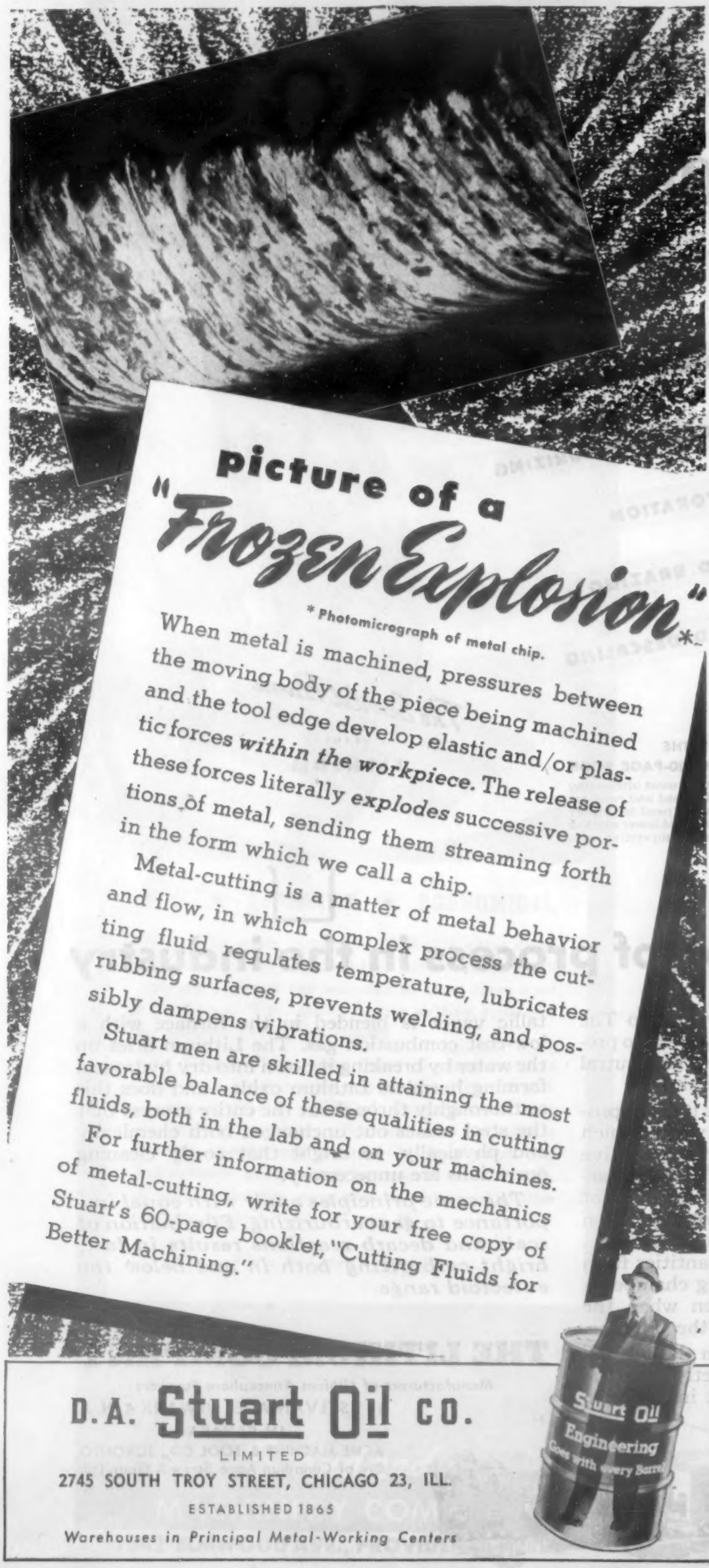

picture of a

"Frozen Explosion"*

* Photomicrograph of metal chip.

When metal is machined, pressures between the moving body of the piece being machined and the tool edge develop elastic and/or plastic forces *within the workpiece*. The release of these forces literally *explodes* successive portions of metal, sending them streaming forth in the form which we call a chip.

Metal-cutting is a matter of metal behavior and flow, in which complex process the cutting fluid regulates temperature, lubricates rubbing surfaces, prevents welding, and possibly dampens vibrations.

Stuart men are skilled in attaining the most favorable balance of these qualities in cutting fluids, both in the lab and on your machines.

For further information on the mechanics of metal-cutting, write for your free copy of Stuart's 60-page booklet, "Cutting Fluids for Better Machining."

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Warehouses in Principal Metal-Working Centers

Small Automatic Bender

A new small-size, high-speed, fully automatic bender for tubing up to 1 in. O.D. is announced by *Pines Engineering Co.*, Aurora, Ill. It is especially adaptable for the tubular furniture, refrigeration, heating

industries and others where high production bending of small diameter tubing is needed.

When equipped with a multiple angle selector, it will make up to 50 tubular chairs per hr., 8 bends to a chair.

A special application for serpentine coils is shown in the inset of the photograph. It contains a booster attachment for automatically advancing the coil to position for the next bend. The machine completes the entire cycle and returns to starting position, including automatic injection, through the start button. Production up to 600 bends per hr. in coils from ⅜ in. O.D. copper tubing is accomplished.

Available are 5 sizes of benders, handling pipe up to 4 in. in diam., as well as bar stock, molding, angles, channels, etc.

Electrical Inspector of Metals

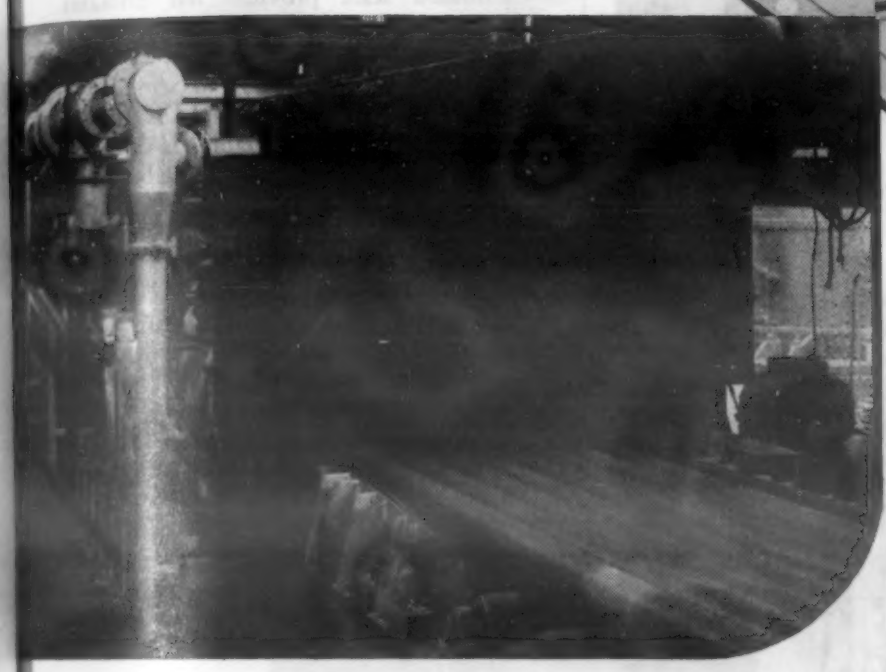
Simple comparisons of ferrous materials as to analysis and heat treatment are provided by the Ferrograph, a new metal-testing instrument just announced by *Allen B. Du Mont Laboratories, Inc.*, Passaic, N. J. This instrument, available on outright sale, can be used to obtain highly useful information about iron and steel very rapidly, just as its larger and more elaborate counterpart, the Cyclograph, is licensed for a far wider range of tests on non-ferrous as well as ferrous materials.

The Ferrograph utilizes the transformer principle of operation. A 23-cycle exciting current is fed into the primary coil while the output of the secondary is controlled by the magnetic characteristics of a metal sample introduced into the coil. The voltage from the secondary is filtered, and the fundamental 23-cycle wave is impressed on the horizontal axis of the cathode-ray tube. The third harmonic is viewed on the vertical axis of the instrument.

The first and third harmonics will vary in phase and amplitude with variations in the analysis and heat-treatment of steel or iron. Sorting of commonly used SAE steels is quite practical, although in some cases the difference obtained is very small and may not be sufficient for sorting production lots of parts. About 80% of the mixtures of

(Continued on page 558)

SALEM'S *Engineered Heat* APPLIED TO TUBULAR PRODUCTS



★

THE REQUIREMENTS—A furnace for draw tempering and normalizing steel pipe, 2 to 14″ in diameter.

THE DESIGN—Horizontal cylindrical type—100′ plus in length.

THE FEATURES—Roller driven hearth; burners firing tangentially into the chamber, providing a rapid, swirling action; two 100′ roller tables at either end; five automatic recording temperature zones in the heating chamber; a rayotube instrument which continuously charts the temperature of all tubes being discharged; two-man operation.

RESULTS—Furnace changes from draw temperature to normalizing temperature in one hour and reverses the change, high to low, in two hours. When normalizing, the furnace heats about 20 tons of pipe in one hour and 18 tons when only draw tempering is required.

Salem combines engineering with economics in designing furnaces to suit specific heat treating requirements. We call this service—

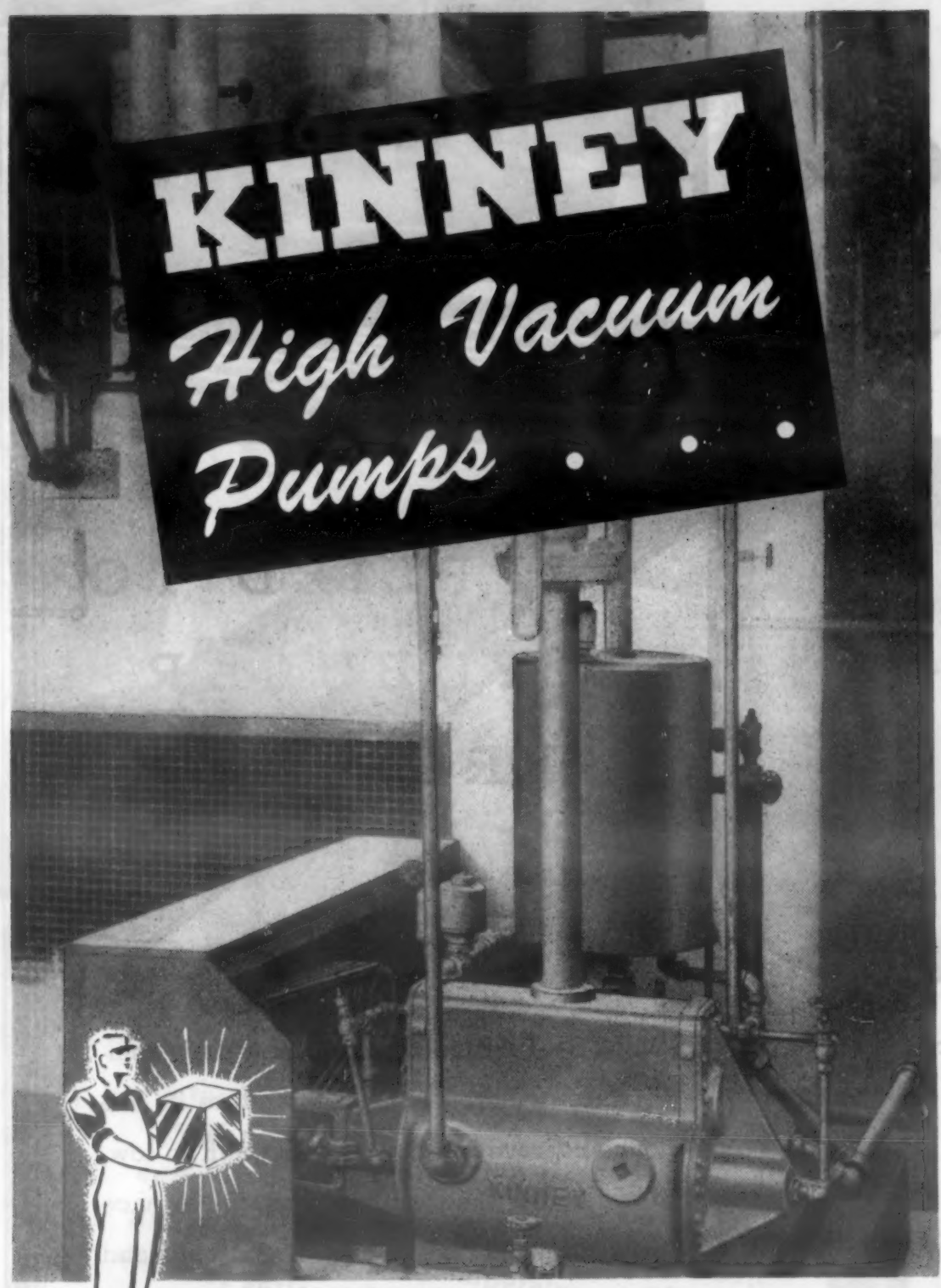
SALEM'S Engineered Heat

NOTE — War production has spurred many sensational developments in heat treating, particularly in controls, quenching and fitting the parts to the method. Salem engineers will be glad to discuss these advances with you.

SALEM **SALEM** OHIO

ENGINEERING CO.

SALEM ENGINEERING COMPANY



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MAGNESIUM PRODUCTION

Magnesium—the feather-light metal with heavy responsibilities—is being produced with the aid of KINNEY High Vacuum Pumps as in this National Research Corp. installation at the Magnesium Plant of the New England Lime Co., Canaan, Conn.

Wherever low absolute pressures must be quickly obtained, as in sintering alloy metals, producing tantalum, preparing blood plasma or penicillin, KINNEY High Vacuum Pumps serve with efficiency and dependability. KINNEY Single Stage Pumps work at low absolute pressures down to 10 microns; KINNEY Compound Dry Vacuum Pumps to 0.5 micron.

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two types of iron or steel that can occur can successfully be sorted by the Ferrograph.

The low-frequency exciting current has an advantage over the use of 60-cycle in that the reversals of magnetizing flux are slow enough to give some appreciable effect from residual magnetism. A long-persistence screen is used in the cathode-ray tube to avoid flicker from the low frequency used. A relay turns the cathode-ray beam off automatically unless there is a sample in the test coil.

The flux in the test coil can be varied widely. It is possible to correlate with different variables by using different flux densities in the Ferrograph coil.

Calibrated scale provides ten divisions per in., with the 10th division accentuated. The instrument operates on 115 v., 40-60 cycles. Dimensions are 12½ in. wide, 17¼ in. high, 23¾ in. deep. Weight is 100 lb. The instrument, fully portable, is designed to withstand rough usage in laboratory, shop, or out in the field.

● A new type of head protector for guarding the head against injuries, known as "Beanie" caps, is introduced by *Portable Products Corp.*, 420 Blvd. of the Allies, Pittsburgh 19. They are made of molded fibre and employ a soft, flexible band that fits any shaped head comfortably. The cap lining and hammock are arranged to cushion the blow.

Straightening Presses

A line of hydraulically operated and accurately controllable straightening presses has been announced by *Colonial Broach Co.*, Box 37, Harper Station, Detroit 13. They will straighten both finished and rough work. The machines are of rugged reinforced welded steel construction with built-in motor and direct acting hydraulic cylinder built into the head of the machine.

Sensitive control is provided through light pressure hand control and foot pedals. A pressure gage mounted on the head of the machine in front of the operator indicates the exact pressure being applied to the workpiece.

Straightening fixtures are equipped with either center or roller type work supports, according to whether finished or rough work (such as forgings, upset shafts, etc.) is to be straightened. These supports are mounted on a long guide rail—particularly useful when long shafts are to be straightened, since they will prevent possible sagging of the work beyond the work anvils.

An important feature of the work supports is that their mounting on the guide rail is through free action rollers. This facilitates rapid shifting of the supports to either side of the ram, for supporting the work at various intervals during straightening.

Ram nose and work support anvils of the new line of Colonial hydraulic straightening presses can be furnished in bronze instead of steel, if desired, to protect finished surfaces during straightening. The machines are available in a number of capacity ratings, ranging up to 50 tons.

36 pages of... HEAT TREAT ★ DATA ★

This entirely new 36 page catalogue is now ready for distribution. Valuable, up-to-the-minute information is presented on Park Salt Baths, Carburizing Compounds, Quenching and Tempering Oils and Protective Coatings. Included also are useful charts illustrating case depths obtained at various times and temperatures in Park's liquid and solid carburizers. Please enter your request on your company letterhead today.

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FLASH-O-LENS consists of a portable 40x microscope combined with a perfect source of illumination in one convenient, compact unit . . . They are available in several models—powered by either standard flash light dry cells or by current from any AC or DC outlet—and with a selection of various combinations of lenses, all interchangeable in the one lens housing.

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Semi-Automatic Specimen Mounting Press

A metal specimen mounting press that is radically new in design is announced by the *Precision Scientific Co.*, 1750 N. Springfield Ave., Chicago 47.

Utilizing air for operation, which is automatically set by a constant pressure reducing valve, it eliminates the hand-operated hydraulic jack usually used. This feature assures uniform specimens, identical in size and hardness, improves polishing characteristics, and greatly reduces the operator's time.

Hot-Forming Molded Laminate

A new *Westinghouse* plastic, known as Micarta 444, combines the desirable molding properties of thermoplastic materials and the good physical characteristics of thermosetting materials. A modification of the resin in standard Micarta causes the substance to soften when hot, as do thermoplastic materials, but at a much higher temperature, about 300 C., which is far above the service range. Thus, the new Micarta can be heated and pressed into deep-drawn and complicated shapes.

The pressures are lower—about 50 to 100 lb.—and the times much shorter than required for curing of thermosetting resins. Dies can be made of hard wood or of thermosetting laminates. This makes the manufacture of a relatively small number of parts from a single die economical, as the cost of these parts is not loaded with the distributed cost of an expensive die.

When cool, the product has the good strength and freedom from embrittlement characteristic of many thermosetting materials. Used in aircraft for non-structural and semi-structural members, a weight saving of some 50% over a comparable volume of metal has been achieved. In addition, a considerable saving in man-hours of labor has been made.

In one particular operation, a single sheet of formed Micarta replaced an airplane part

(Continued on page 562)

Your laboratory and production-control people can quickly learn to use this super-magnifier

Factory-production specialists, as well as research workers and disease fighters, now have available a compact, easily-operated super-magnifier in this new console-model equipment. Permits direct observation at five thousand diameters. Built-in camera makes it a simple matter for practically anyone to make good micrographs quickly. Instrument operates from any ordinary 110-volt A. C. light socket.

The instrument shown in the small picture at the left is the RCA "Universal" model, which permits direct magnifications ranging from 100 to 20,000 diameters, in 40 steps. This is the last word in modern microscopy.

A special RCA booklet, amply illustrated, gives complete descriptions of and specifications for both of these instruments. A copy of this booklet will be sent to you promptly, on request.

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formed of four separate pieces of aluminum. The aluminum sections were welded together. Forty inches of weld were saved, which contributed to the 1¼-man-hours required for the aluminum part. The formed Micarta part requires 19 min. to produce, and weighs but half as much. These savings indicate the possibilities afforded by the material in applications where good insulating qualities, high impact strength, and good thermal stability are required.

New Aluminum Alloy

A new aluminum alloy has been developed by the *Reynolds Metals Co.*, Louisville, Ky., and is being manufactured for fighting planes, jeep wheels and other implements of war, Paul P. Zeigler, chief metallurgist, announces. The maker claims that, considering useful strength, it is the strongest aluminum alloy available for general commercial use.

The alloy, known as R-303, is made of aluminum, magnesium and zinc. It has over two times the compressive yield strength of structural steel. Its greater strength will enable airplane manufacturers to build lighter and stronger planes with resultant increases in their payloads, such as bombs, guns and freight. This alloy is free of the defects, susceptibility to corrosion and stress cracking, which for years have made similar alloys impractical for use in aircraft.

Tests have shown R-303 to be from 85 to 110% stronger than structural steel in yield strength and 70% stronger in yield strength than other high-strength aluminum alloys. Its tensile strength in extruded shapes has run as high as 90,000 p.s.i.

Fabricating processes have been developed in the company's plants at Louisville, Ky., and Sheffield, Ala., for the production of sheet alloy as well as for extrusions, forgings, rolled rod and bar products. When peace comes, it will be used for railroad equipment, automotive parts and heavy machinery, as well as for baby carriages, furniture and other light household articles.

News of Engineers

Dr. R. C. Benner, director of research, Carborundum Co., for the past 18 years, retired from that position as of Jan. 1. During his 40 years of business experience he has been a patent attorney, registered engineer and a professional inventor, holding more than 250 patents, covering abrasives, refractories, electric furnaces and other fields. After a brief rest he will do consulting research work. He is a member of 11 societies, mostly technical.

Dr. C. G. Suits, formerly assistant director, succeeds *Dr. W. P. Coolidge* as director of the General Electric research laboratory, effective Jan. 1.

Dr. Max Muller, formerly superintendent of refractories, Basic Magnesium, Inc., Las

PREPARE ALUMINUM SURFACES FOR
Spot Welding
by using
NEW
OAKITE
PROCESS

A new Oakite process has been designed for preparing aluminum for spot welding . . . a technique that employs two newly developed, specialized materials: Oakite Composition No. 61 for precleaning; Oakite Compound No. 85 for deoxidizing surfaces.

Removal of the new-type identification paints and stencil inks now widely used can be speedily accomplished without hand swabbing by pre-cleaning aluminum in recommended solution of highly active yet SAFE Oakite Composition No. 61.

Sheets are then rinsed and immersed in solution of Oakite Compound No. 85 at room temperature. This acid-type material frees aluminum of oxide film with SPEED and SAFETY . . . does not develop smut on Alclad . . . leaves surfaces in excellent condition for MORE UNIFORM welds. Oakite Compound No. 85 comes in powder form, is easy to handle. It is unusually economical.

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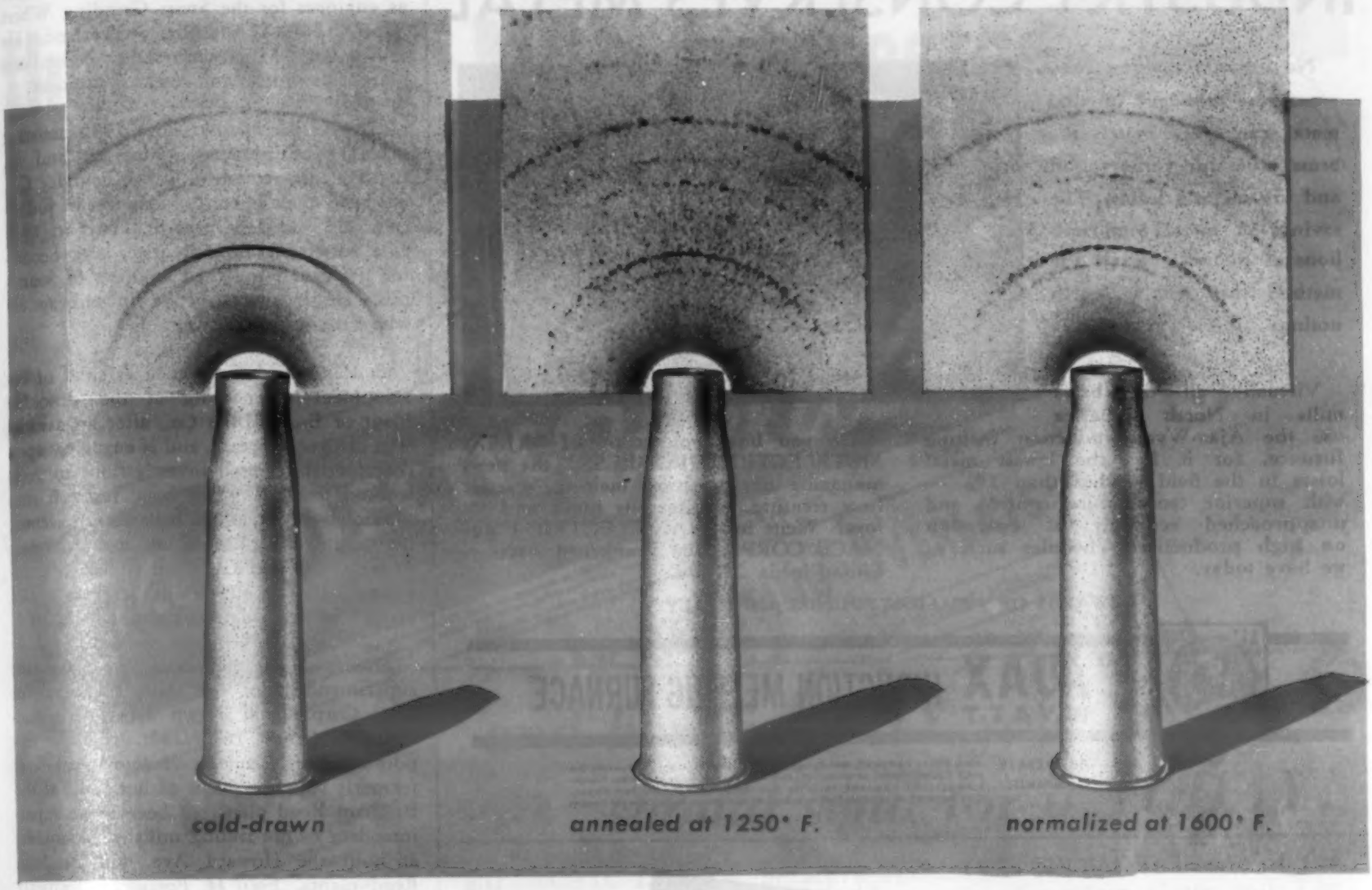
exactly how does heat treatment influence structure?



hese are cartridge cases, cold drawn of steel containing .27% carbon and .67% manganese. They are worked from hot forged cups in four cold draw passes, and normalized at 1600° F. after each pass, except the final one.

In setting up original techniques for such operations, how can you be *sure* that a given procedure is the most efficient means to achieve desired properties? And, once set, what's the best method of control to maintain adherence to the technique?

Metallurgists are finding in x-ray diffraction an ideal answer to these problems, because it gives them (as in the typical examples above) a precise picture of the actual molecular architecture of the material at every stage of processing. X-ray diffraction is a tool of every-day utility whose far reaching possibilities in product research, control, improvement and development are definitely worth your investigation. The coupon here will bring further information.

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METAL TREATING INSTITUTE

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Vegas, Nev., has been placed in charge of research and experimentation of Titan Abrasives Co., Chicago, maker of Besly Titan abrasive wheels. He started his career as engineer for the Swiss Grinding Wheel Works, Ltd., Winterhur, Switzerland. He joined Basic Magnesium shortly after Pearl Harbor as project and research engineer.

George W. Mitsch, since 1935 assistant manager of foundries, Madison and St. Louis plants, American Car & Foundry Co., has been made operating manager of foundries. He joined ACF at St. Louis in 1913 as a patternmaker apprentice, later becoming draftsman and then engineer of foundries. He has been active in railway car wheel design and testing.

E. V. Crane has resigned as chief of development engineering at the Brooklyn plant of E. W. Bliss Co., after an association of over 24 years, and is engaging upon confidential research investigations in press worked materials. His basic research into plastic flow phenomena have been presented before university groups and many chapters of American and Canadian engineering societies. He is author of textbooks and articles in the technical press.

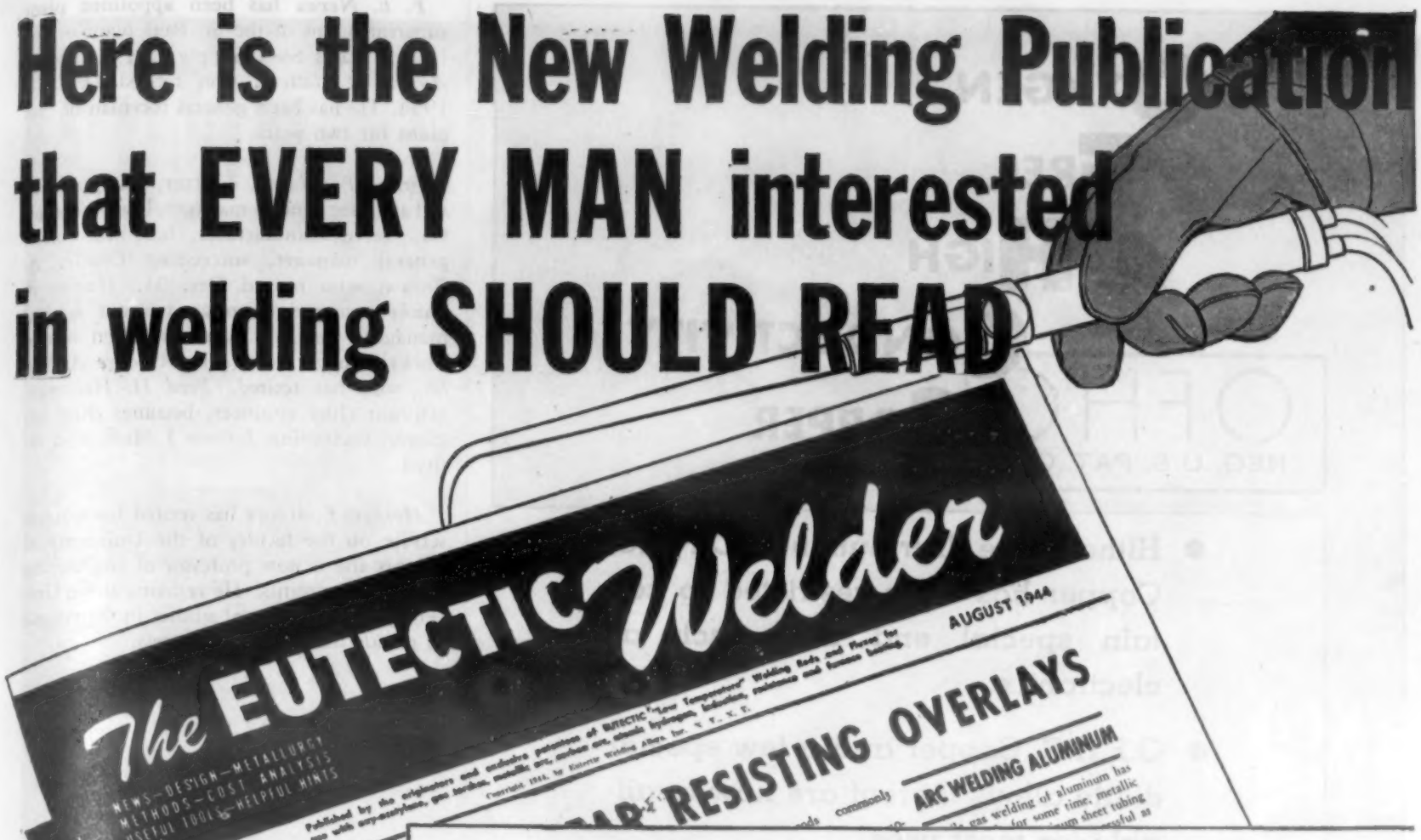
Stanley Szacik has been made assistant superintendent of the Allegheny Ludlum Steel Corp.'s cold drawn department, succeeding *Arthur H. Hanks,* recently appointed superintendent. *Anthony Passafaro,* formerly superintendent of hot mills at the Brigham Road plant has been made superintendent of hot rolling mills and hammers at both the Howard Ave. and Brigham Road plants. *Emil H. Forsstrom,* formerly foreman of the finishing department of Brigham Road, has been made assistant superintendent of the Brigham Road plant. *William K. Powers,* formerly night supervisor at Brigham Road, has been appointed assistant superintendent of the hot rolling mills at that plant.

Justice W. Lehr has become district manager of the Chicago plant of the American Car & Foundry Co. He has been with the Pullman Co., Mt. Vernon Car Co., Curtis Bay Copper Iron Works of Baltimore and the Sanford Day Iron Works, Knoxville, Tenn. He joined ACF in 1940.

Edmund A. Georgi, formerly manager, technical development, Papermakers Chemical Dept., Hercules Powder Co., has joined the research and development of the Pennsylvania Salt Mfg. Co., as director of Special Products div., which embraces electrochemicals, detergents, etc.

L. H. Skougor has been made general manager, Continental Can Co.'s production planning department, having formerly been manager of the company's plant in Jersey City. *E. B. Dullinger* has been appointed factory manager of Continental's recently acquired Clearing-Owens plant in Chicago. *K. W. Houck* has been made industrial engineer of the same plant. *J. Fedosky, Jr.* is a representative of the vice president in charge of manufacturing. *R. J. Humes* becomes factory manager of the company's plant at Wheeling, W. Va.

Here is the New Welding Publication that EVERY MAN interested in welding SHOULD READ



These features each month keep you posted on all developments and up-to-the-minute welding news

- ★ WELDING METALLURGY
- ★ WELDING DESIGN
- ★ PRODUCTION IDEAS
- ★ SALVAGING TOOLS
- ★ NEW MAINTENANCE IDEAS
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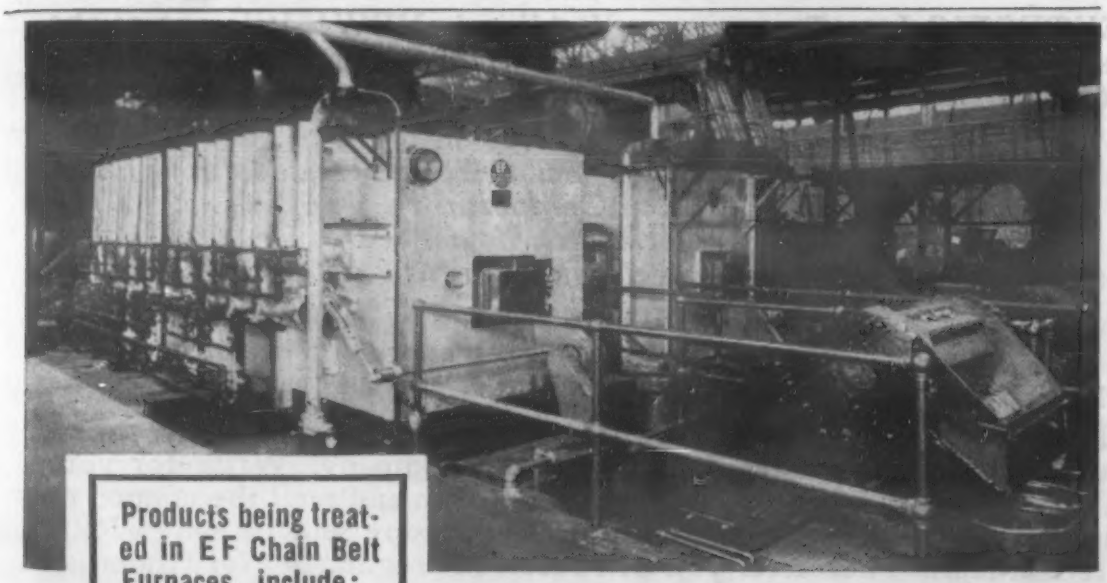

Products being treated in EF Chain Belt Furnaces, include:

Sprockets
Cap screws
Bolts and nuts
Gears and pinions
Flat springs
Coil springs
Small forgings
Valve springs
Spring plates
Tractor links
Rivets and washers
Wrench & tool parts
Bearing parts —cups and cones
Machine gun cartridge clips
Aircraft engine parts
Automotive parts
Rock bits, and many other products

For Hardening Small Parts

175 to 2000 lbs. per hour

Uniformity — Scale-Free — Continuously

The above gas fired radiant tube chain belt furnace is one of three we installed in one plant. Hundreds are in operation handling products such as listed at left. We build them for gas, oil or electrically heated.

The EF chain belt conveyor type furnace is one of the most satisfactory general purpose furnaces built for the continuous, uniform, economical production heat treatment of small and medium size products. We will be glad to send complete data on these and other types we build.

Send for circulars showing the chain belt and other types of EF production furnaces

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces—For Any Process, Product or Production

F. E. Neveu has been appointed plant superintendent of the St. Paul plant of the United States Steel Supply Co., succeeding *Austin E. Slattery,* who retired Dec. 31, 1944. He has been general foreman of that plant for two years.

Frank P. Rhame, director, vice-president and assistant general manager, Lunkenheimer Co., valve manufacturer, has been made general manager, succeeding *Charles A. Brown,* who retired Dec. 31. *Homer E. Lunken* succeeds him as assistant general manager. *Carra L. Lane* has been named works manager, succeeding *George A. Seyler,* who has retired. *Fred H. Hebeman,* assistant chief engineer, becomes chief engineer, succeeding *Jerome J. Aull,* who retired.

Herbert F. Moore has retired from active service on the faculty of the University of Illinois and is now professor of engineering materials, emeritus. He remains at the University, making special studies in the fatigue of metals under repeated stress.

House Organ Notes

Aluminum News-Letter, Aluminum Co. of America, Dec. 1944.

"We have a bone to pick with the alchemists when it comes to terminology. They divided all metals into 'noble' metals and 'base' metals. According to them the noble metals were those of comparatively high value, such as gold, silver and platinum. Lead, zinc and iron were base metals. They classified them also in other ways. The more inert, the more noble. We object to their practice of calling high-priced ones 'noble' and the low-priced ones 'base.' Under this kind of set-up, aluminum has been getting baser and baser for 50 years. To us, the more plentiful and economical aluminum becomes, the more noble. If there are any alchemists in the house who'd like to argue the point, we'll be glad to meet them out in the alley after the show."

Pig Iron Rough Notes, Sloss-Sheffield Steel & Iron Co., Autumn-Winter, 1944-45.

"A thing of great excellence may become such a part of our way of life that to some extent it is actually ignored and forgotten as far as possible. At Pearl Harbor gray iron was hardly mentioned in polite Army, Navy and engineering circles. This was the great steel age and war plants held no place for 'mere cast iron.' Some of the substitutes for cast iron began to fall by the wayside. Gray iron was rediscovered by the nation. Higher-ups suddenly realized that this forgotten material did have a place. With the foundries already taxed to capacity, efforts were redoubled to help meet the many new calls for castings for the heavy truck program, tanks, etc. The foundry industry faces a bright future, for no material has ever been developed that can compare with its wide adaptability and uniformly low cost."

HERE'S A PICTURE OF LICKED LIMITATIONS

When you look at a small part by Pomet, you usually see an example of how the limitations of conventional production methods were overcome.

Pomet powder metallurgy opens up a whole new field of possibilities in the fabrication of small parts in bronze, iron, steel and other metals. It widens the scope for designers of wartime products and promises new economies in peacetime production.

If you need dense, intricate parts in quantity, it will pay you to learn more about the new Pomet techniques.

Special characteristics like hardness, ductility, wear resistance and tensile strength can be incorporated to order. Machining is either entirely eliminated or reduced to a minimum.

We will be pleased to quote on blueprints or specifications, or send you literature on request.

CLOSE TOLERANCES WITHOUT MACHINING

HIGH DENSITY

POMET

DUCTILITY OR HARDNESS

COMBINED MATERIALS

WEAR RESISTANCE

POWDER METALLURGY CORPORATION

A SUBSIDIARY OF GENERAL BRONZE CORPORATION

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CLEANING COMPOUNDS

You may have Metal Cleaning Problems in 1945

Let us help you with them

There will be new materials, improved processes, faster production—greater demands on industry this year. War needs towering over all.

In metal fabricating, CLEANING prior to finishing is highly important. Using the right cleaner is vital. At hundreds of plants—large and small—PERMAG Compounds are doing the metal cleaning job, removing grease, oil, shop dirt, all foreign matter quickly and efficiently from steel, brass, copper, aluminum and other soft metals, leaving the surface chemically clean for finishing operations.

PERMAG Compounds work economically; they have given unqualified satisfaction for 21 years wherever used.

If you are having difficulty with new finishes or materials on metals, our Cooperative Service may be of valued help to you. Don't fail to call on us. Write, wire or 'phone.

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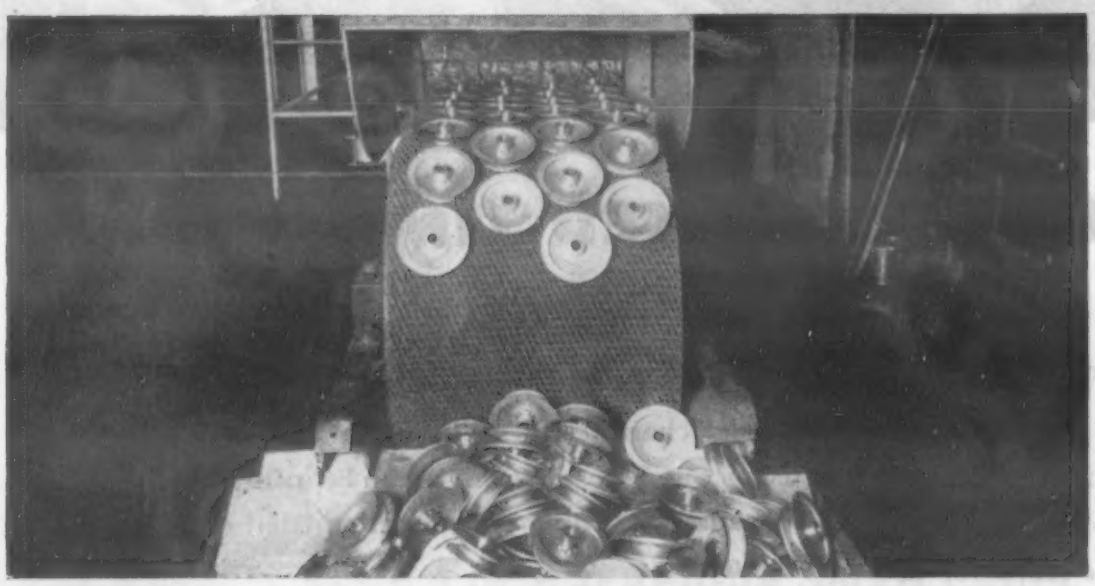


The Complete Assemblies are Discharged
Securely Joined, Bright, Continuously
. . . from EF Brazing Furnaces

Products requiring several stampings joined or requiring screw machine parts, forgings and stampings to complete the unit, can be neatly and economically joined right in your production line.

Strong, leak-proof joints are made and the completed unit is discharged from the furnace —clean and bright.
Any number of joints in the same product or any number of pieces can be joined at one time.

Investigate This Process for Joining Your Aluminum, Brass, Copper or Steel Parts.

Send for printed matter showing various types of EF brazing furnaces.

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

The Parkerizer, Parker Rust-Proof Co., Nov.-Dec. 1944.

"It was at first believed popularly that land mines were defensive weapons to protect the rear of retreating armies or certain defense areas. But they are now used extensively by us in offensive operations to protect 'spearheads' penetrating enemy country, and have become vital equipment. A large part of the Army's new anti-tank M-6 mines are produced by Rheem Mfg. Co. They are usually placed on the flanks of spearheads to prevent enemy tanks from encircling an extended spearhead. Later the mines are recovered so that they will not endanger the increased Allied personnel. Their success in France points to their use against the Japs. Rheem Bonderizes and paints these mines. They must be hermetically sealed, and require an 'air test' to make sure they will not leak."

Wheelco Comments, Wheelco Instruments Co., Nov.-Dec. 1944.

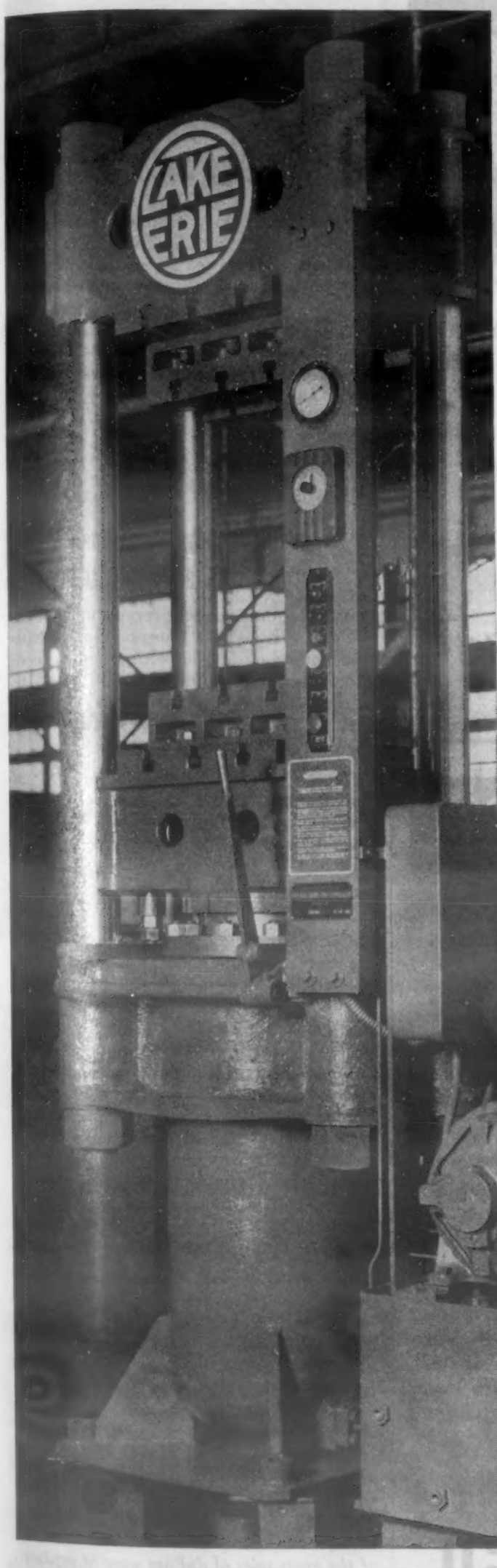
"The art of making pottery has been practiced by all primitive peoples since the beginning of man. Early pottery was dried in the sun to hardness and sometimes covered with a greasy material that produced a semi-glazed effect that rendered the ware less porous. One of the first examples of fired, glazed pottery is represented by Ushabti figurines buried in the tombs of Egypt around 3000 B.C. Greek pottery dates back to 400 B.C. and is noted for its exquisite beauty, especially with vases. Porcelain was invented in China in 185 B.C. Salt glazing was begun in England in 1670, when it was found that ordinary salt introduced into the furnace during firing vaporized and was deposited on the ware surface as a glaze. It is indeed a long way from the early sun-drying practice to modern methods using electricity as the heating agent for baking and glazing of pottery."

Mead Alcoan, Aluminum Co. of America, Mead, Wash., Christmas, 1944.

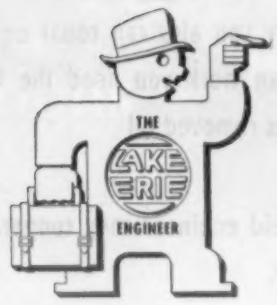
The Great Northern Railway has completed in its St. Cloud, Minn., shops the first car in the history of American railroads having a complete aluminum exterior. Having a 100,000-lb. capacity, its loading capacity is more than three times as great as standard box cars of a decade ago. The saving in weight is 4057 lb. Aluminum alloy is used, held by aluminum rivets. Its first use will be for high-speed express cargoes in passenger trains.

Bendix Radio Engineer, Bendix Aviation Corp., Jan. 1945.

"Emphasis is consistently placed on the familiar slogan: 'One test is worth a thousand expert opinions.' For measurement, comparison and inspection of gear teeth, threads, springs, or other irregularly shaped production parts, a Bausch and Lomb contour measuring projector provides unique advantages. Using the principle of optical projection, it does in a few minutes what would otherwise take hours to complete. The object can be magnified from 10 to 100 times and checked without friction or the deformation resulting from contact with a measuring anvil, which frequently occurs when micrometers are used. A favorite demonstration is made with a $5 bill on which the names of the states appearing on the frieze of the Lincoln Memorial are



PILOTING THE FUTURE OF PLASTICS



This 200-ton Lake Erie Plastic Molding Press was built for the Durez Plastics & Chemicals, Inc., of North Tonawanda, N. Y.

It is used in the Durez Pilot Laboratory to experiment with and test out the many products, present and future, which can be manufactured more efficiently and more economically out of Durez Molding Compounds.

Lake Erie has its eyes focused on the great future of the Plastics Age. Already we have designed standard compression molding presses that can be adapted to your needs—or we can build presses to meet any special production methods you may require. Write for complete information.

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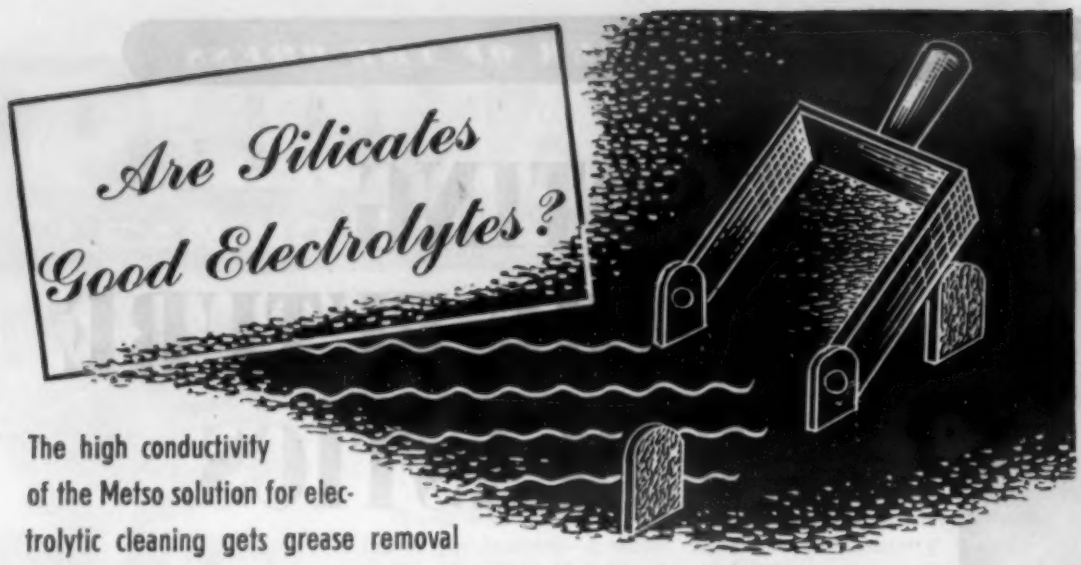

The high conductivity of the Metso solution for electrolytic cleaning gets grease removal under way promptly. And under high current density you also can count on stable cleaning baths. For a steady flow of chemically clean work you need the help of the balanced soluble silica content of Metso which prevents removed oil and grease from redepositing on the clean parts.

Have you a cleaning problem with which a Metso field engineer may cooperate in solving? Write us today.

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C-F POSITIONERS

When "Position" Counts Most

On automatic welding jobs, like the one illustrated here, position counts "most," and with the C-F Positioner (with 6 sizes, and capacities to 30,000 lbs.) the tables tilt to 135° beyond horizontal and rotate 360°, all under push button control. The exclusive C-F Variable-Speed Control gives table rotations ranging from 0 R.P.M. up for all sizes. For "quick change" of position, for greater time saving and efficiency, for lower costs and greater safety to men and materials, specify C-F Positioners for all *automatic* and production welding operations.

Write for Bulletin WP-22

CULLEN-FRIESTEDT CO.
1314 S. Kilbourn Ave. **Chicago 23, Ill.**

so enlarged they are read with ease. It is possible to measure angles to the accuracy of 1 min. and size to an accuracy of 0.001 in."

Circuits for Victory, Western Electric, History of its First 75 Years.

"The electrical gun director, developed by Bell Telephone Laboratories and made by Western Electric, has been termed by military experts 'one of the greatest advances in the art of fire control made during this war.' Used on every front, it brings a new order of accuracy to the fire of anti-aircraft guns. On a typical day 143 buzz bombs reached the English coast, 65 of which were destroyed by anti-aircraft guns. The director is a triumph of the art of electronics. Employing more than 100 vacuum tubes, it solves in 15 sec. mathematical equasions that would take a trained man over 5 hr. Its development required the experience of 400 laboratory engineers who often worked day and night."

Briefs on Associations, Promotions and Education

Lubrication engineers, representing prominent industrial and transportation companies and educators, have organized a non-profit body as the American Society of Lubrication Engineers, 135 S. La Salle St., Chicago 3. The president is C. E. Pritchard, Republic Steel Co.

The Electron Microscope Society of America has set up two new committees: One on awards for outstanding papers at annual meetings; one for discussion of problems of resolution. New officers were elected recently, the president being James Hillier, RCA Laboratories, Princeton, N. J.

Completing the first year of its existence, the Cutting Tool Manufacturers Assn. has re-elected eight former directors, while adding four new ones to the list. The surplus tool disposal plan developed by this association a year ago has been in successful test operation in Chicago under direction of the Army Air Force. Such tools would be disposed of by manufacturers at a ratio of one surplus tool to every new tool of a similar type made by the company. The tools would be "sold" to the original manufacturer at discounts from the original price up to 40%.

Greatly increased research programs, designed to "make up the lost time" in improving the American standard of living will be launched by the chemical industry once its laboratories have been relieved of war duties, Dr. Elmer K. Bolton, chemical director of duPont, said in accepting the Perkin medal awarded him for outstanding accomplishments in industrial research. However, he mentioned a serious shortage of well-trained chemists—one that will be felt for years. The award was made by the American section, Society of Chemical Industry. He said that in 1942 almost half of the gross sales of duPont were of products unknown or non-commercial in 1928.

More than 32,000 industrial establish-

Turbosupercharger Buckets are made from a HAYNES STELLITE Alloy

• **Buckets in the wheels of airplane turbosuperchargers are driven by the impingement of exhaust gases at 1,500 to 1,600 deg. F., and rotate at speeds so high that a ½-oz. bucket is subjected to centrifugal force of 750 pounds.**

A HAYNES STELLITE alloy is used because it withstands the severe conditions of high temperature, corrosive gases, vibration, and centrifugal stresses over long periods of time. No other economically practical metal has been found for this service.

The same properties that make this HAYNES STELLITE alloy so essential in turbosuperchargers are also important in many other applications where severe conditions of heat and corrosion are encountered.

Consider HAYNES STELLITE alloys for those jobs where other metals fail. Our engineers will help you use them economically and efficiently. Write for further information.

Only HAYNES STELLITE Alloys Offer All These Advantages

1. **They resist wear and abrasion.**
2. **They maintain their hardness even at red heat.**
3. **They retain their good mechanical properties at high temperatures over long periods of time.**
4. **They resist atmospheric corrosion and corrosive chemicals.**
5. **They take and keep a high polish.**
6. **They have a low coefficient of friction.**
7. **They are practically non-magnetic.**
8. **They can be supplied in the form of castings, small sheets, and welding rod.**

HAYNES STELLITE TRADE-MARK

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Unit of Union Carbide and Carbon Corporation

New York 17, N. Y. UCC Kokomo, Indiana

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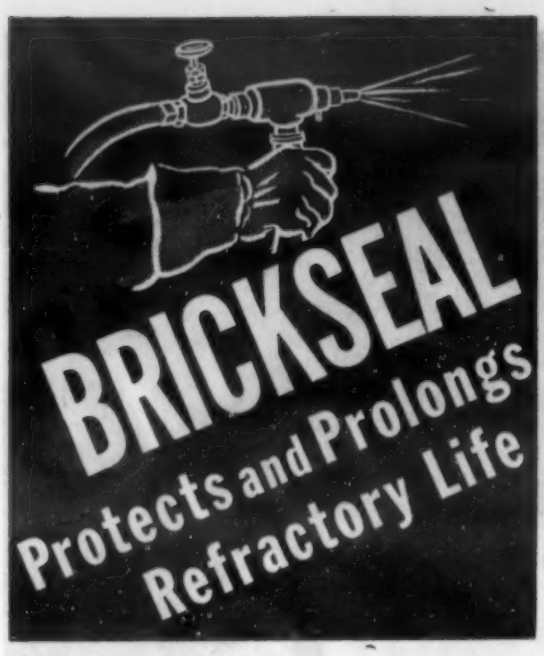
RED-HARD, WEAR-RESISTING ALLOY OF COBALT, CHROMIUM, AND TUNGSTEN.

"HAYNES STELLITE" is a registered trade-mark of the Haynes Stellite Company.

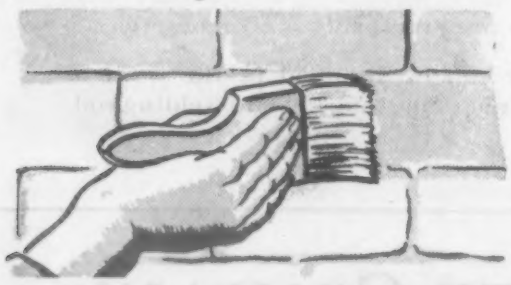


Applied like paint, prevents cracking and spalling

Now, more than ever, anything which prevents interruption of furnace production is of vital importance. Brickseal refractory coating prolongs the life of new or old brickwork by preventing disintegration due to cracking, spalling and slagging.

Brickseal consists of high-fusion clays and metals combined in oil. Furnace heat drives off the oils and vitrifies the clays and metals, permanently binding the bricks with a highly-glazed, vitreous, monolithic coating, impervious to gases, carbon and air infiltration. The highly reflective surface keeps heat inside the furnace and increases its efficiency.

At operating temperature Brickseal becomes semi-plastic so that it expands and contracts with the wall, and therefore cannot crack, peel or blister due to sudden temperature variations. This feature also enables Brickseal to bind loose brickwork and old cracks. Slag and clinkers can be removed without damage to lining. Brickseal is applied easily with brush or spray gun, and the furnace may be fired at once. At very little cost, Brickseal will assure longer, uninterrupted production. Write for sample.



BRICKSEAL
REFRACTORY CO.
1029 CLINTON ST., HOBOKEN, N. J.

ments, an all-time record, now participate in organized apprenticeship programs registered with the War Manpower Commission. It indicates that employers and labor recognize the need for revival of training of all-round skilled workers. More than 1,000 veterans of this war have been enrolled in apprenticeship programs.

Two annual awards totaling $700 for engineering student papers of outstanding merit on designated subject gray iron research have been established by the technical committee of the Gray Iron Founders' Society, Cleveland and Washington. First prize is $500; second prize, $200, the contest closing Aug. 5. Subjects for the 1945 contest are: Creep values at 600 to 800 F., elongation, impact values, machinability, and modulus of elasticity.

"American Malleable Iron—a Handbook" has been published and distributed by the Malleable Founders' Society, Union Commerce Bldg., Cleveland 14. It gives full discussion from its chemistry, metallurgy and manufacture to its applications in various fields. It brings together for the first time in one unit complete data on present manufacturing procedures and most recent standards and practices.

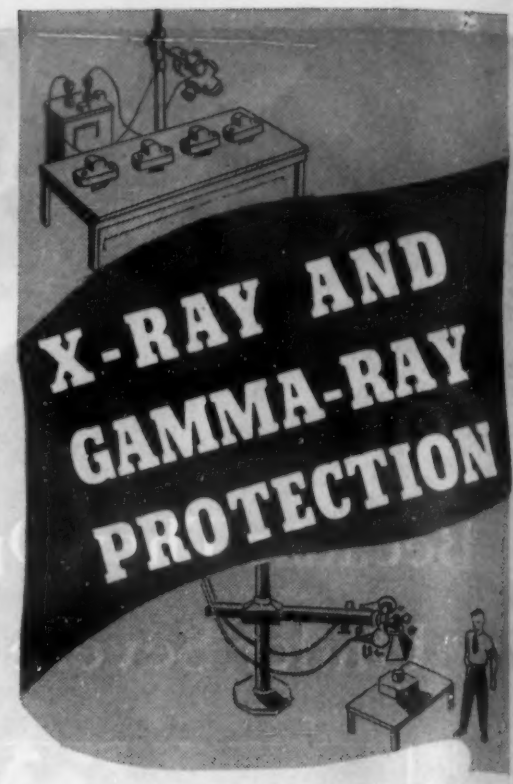
Livingston W. Houston has been elected president of Rensselaer Polytechnic Institute, Troy, N. Y., the country's oldest college of engineering and science. He was formerly president of the Ludlow Valve Mfg. Co. He was graduated from the school, served as trustee for 20 years, and has been active in its management for over 10 years.

The American Standards Assn. has re-elected as president Henry B. Bryans, executive vice president and director, Philadelphia Electric Co.

The first chapter of the American Foundrymen's Assn. to be organized in the Pacific Northwest is that recently established at Portland, Ore., being the 29th chapter. This is the third chapter on the Pacific Coast. Prominent in the newest chapter is William R. Pindell, Northwest Foundry & Furnace Works, Portland.

At least 92% of the 4,309 graduates of the War Industries Training School of Stevens Institute of Technology have applied their training directly on war jobs, while 25% either obtained a war job or advancement in a war job as a result of the training. Average age of students is now 32½ years.

● Vacuum impregnation of coils, armatures, transformers, etc., under pressure is demonstrating many advantages over ordinary dipping, and costs no more, according to *Vacuum Impregnating Works*, 638 Federal St., Chicago. Among the results in addition to more efficient insulation are: Higher sustained voltages without overload; elimination of wear due to creeping of coils; prevention of insulation charring; protection of wire from vibration; permanent filling of spaces; maintenance of coil coolness; coils rendered positively moisture-proof; protection of windings from electrolysis.



YOU may rely on us to solve all problems attendant upon the use of protective equipment . . . and to supply a material and method to meet U. S. Bureau of Standards requirements. Our engineers will submit plans and specifications on any problem of production, testing, or general protection of personnel. No obligation, of course!

Among Those We Serve!

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Fairchild Aviation
Wright Aeronautical
Sperry Gyroscope
Federal Shipyards
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Other Installations on Request!

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. . . contains description of materials, methods, installation procedure, diagrams, specifications, etc.

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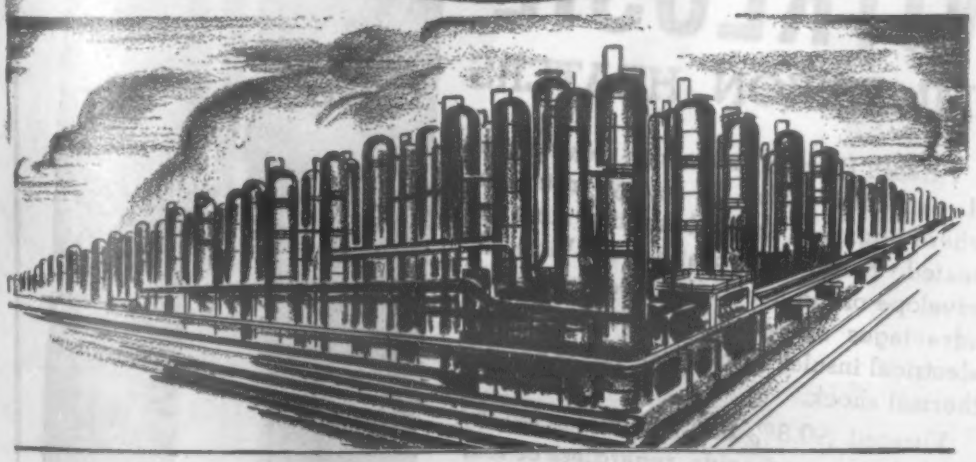

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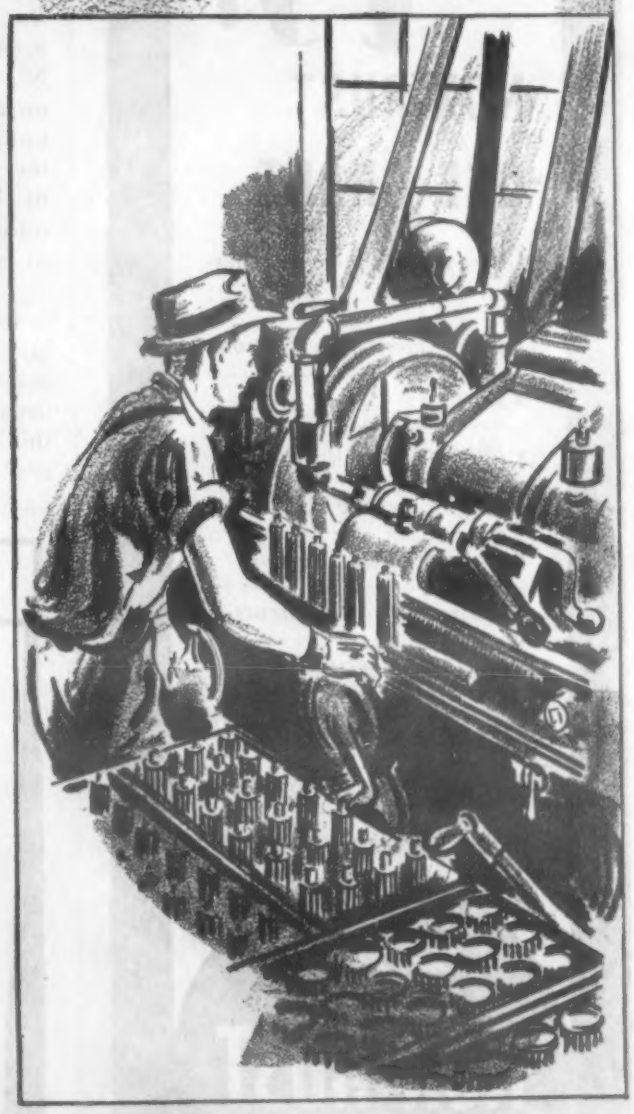

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SINCLAIR *IS EQUIPPED TO SERVE YOU BETTER!*

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Gives you all latest information complete at a glance:

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- *physical description*
- *type of coating*
- *method of application*
- *protection requirements*
- *and other pertinent data.*

The NOX-RUST use chart is designed for ready reference and printed on heavy paper suitable for hanging. Supply limited. Send for it today.

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sent free a simple request on your firm letterhead will bring you this new chart by return mail.

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CHICAGO 8, ILL.

Plants and Slants

A study of the Pacific Coast steel industry to determine how supply of steel can be increased and cost reduced is being undertaken by the *Los Angeles Chamber of Commerce.* The steel committee is headed by Alden Roach, president, *Consolidated Steel Corp.* The study will be concerned with new steel mills at Fontana, Cal. and Geneva, Utah, and will consider whether they can operate in post-war under private ownership; what change in facilities will be needed to change to peace time products; what steps will be needed to lower costs and prices. It may be recommended that they be turned over to private ownership. Consideration will be given freight rates, types of products in demand and market conditions generally.

The first dioramic display to employ motion in three elements—on land, sea and in the air—has been built by the *Timken Roller Bearing Co.* for the Museum of Science & Industry in Rockefeller Center, N. Y. The display shows a landing scene on the Normandy coast. All equipment is built to scale and also made to conform to the rules of perspective. Airplanes seem to fly by moving the background. Shifting colors portray cycles of daylight from dawn to dark.

Inland Steel Co. has established a metallurgical and inspection department by merging its Indiana Harbor works metallurgical department and inspection department and the general office department of inspection and metallurgy. The purpose is to create more unified control and correlation. It will be headed by J. Hunter Nead as manager, with principal office at Indiana Harbor.

Western Cartridge Co. has been merged with the Olin Corp. to form *Olin Industries, Inc.* as the parent company. It will operate seven divisions and four subsidiary corporations. Meanwhile, Franklin W. Olin retires as president of the Western Cartridge group after 52 years of active management of a business which he started as a small powder mill in Illinois.

The new alumina development laboratory of *Aluminum Research Laboratories, Aluminum Co. of America,* at E. St. Louis, Ill., was recently inspected by editors of technical magazines. The principal project of the new laboratory will be working on new methods for extraction of alumina from low quality ore. Among the problems are: there are more impurities, some of which are troublesome; more waste to be disposed of; and the material filters differently. The new building is brick and steel, 80 ft. wide by 340 ft. long, with a total of 46,300 sq. ft. of floor space. Regular equipment for the conventional Bayer process for low silica ores is augmented by other equipment for high silica-low grade ores. Hence, the new technique is the "combination process." In the laboratory is machinery that reflects on a small scale the equipment used in mass production. The cost of the new laboratory and outfit amounted to $750,000.

VITREOSIL

IMMERSION HEATERS

Vitreosil Electric Immersion Heaters are of particular value in many instances where liquids of an acid reaction must be heated. For such applications, the Vitreosil envelope of the heating unit combines the advantages of being acid-proof, a good electrical insulator, and resistant to severe thermal shock.

Vitreosil (99.8% SiO_2) is unaffected by all halogens and acids, regardless of temperature or concentration, with the exception of fluorine and hydrofluoric and phosphoric acids.

Vitreosil Electric Heaters are available in lengths ranging from 10 to 30 inches with k.w. ratings of .25 to 5.0.

Write for full details and quotations on Vitreosil Electric Immersion Heaters.

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